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The following are particularly required for the Society's collection:—

1. Orthodontic appliances that have been in common use in the past.

2. Orthodontic instruments from the past.

3. Series of models, preferably from birth to adulthood, of untreated cases. Normal occlusions would be particularly welcome, as would copies of cephalometric records.

4. The Chapman Collection (Northcroft classification):—

a. Large labial fraenum.

b. Gemination of deciduous and permanent teeth.

Diminutive teeth.

c. Total anodontia.

d. Delayed eruption due to general conditions.

Complete submergence of deciduous teeth.

e. Radiographic records of extra teeth.

f. Rotation of premolars.

g. Inversion of unerupted upper central incisors and lower first permanent molars.

h. Crowding of incisors or premolars.

i. Infraclusion of deciduous molars.

j. Malrelationship of dental arches, illustrated by study models, cephalometric and photographic records.

k. Examples showing early loss of upper deciduous molars, permanent incisors, and first permanent molars, preferably before and after the loss.

l. The effects of traumatic injury, if possible showing the condition before injury.

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SMITH, A. B. (1965), *Dent. Practnr dent. Rec.*, **15**, 123.

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JONES, C. D. (1984), *A Textbook of Orthodontics*. Bristol: John Wright.

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Toutountzakis, N.
Tsaltas, G. K.

Hong Kong
Mak, K. L.
Tsang, Y. S.
Yin-Cheung, Wu, S.

India
Ghosh, A. S.

Italy
Magni, F.

Jamaica
Lyn, M. R.

Malaysia
Chan, B. K.
Cheah, C. K.
Choo, S. B.
Lee Chin Kung
Leong, C. T.
Lye Thim Loke, Mrs.
Ping, S. T.
Sundararaj, Mrs. S.
Tam, M. F.

Malta
Demajo, A.
Manara. G.

New Zealand
Ashby, J. W.
Bell, W. P. L.
Cook, C. C.
Gilbert, G. H.
Harkness, E. M.
Lang, E. T.
Valentine, H. B.
Willis, L. E.

Norway
Aamodt, A. C.
Engh, Olav
Johannesen, Børge
Krogstad, Olav, Jun.
Selmer-Olsen, Prof. R.

Rhodesia
Robson, F. F.

Singapore
Onn Lee Chee
Choo, T. C.
Lye, T. L., Mrs.

S. Africa
Braude, B.
De Muelenaere, J. J. G. G.
De Villiers, J. F.
Fainsinger, B. E.
Melville, R. G.
Miller, B. H.
Mizrahi, E.
Oosthuizen, L.

S. America
Brears, O. B. (Ecuador)

Sweden
Ahlgren, J.
Granerus, R.
Granse, K. A.
Ljungdahl, L.
Lundström, Prof. A.
Pihl, Miss E. M. K.
Tegner, G.
Volmer Lind, H. C.

Switzerland
Hotz, Prof. R.

U.S.A.
Bell, L. A.
Blausten, S.
Coval, N. M.
Goldstein, M. C.
Gosman, S. D.
Gottlieb, A. W.
Grossman, R. C.
Moss, G. W.
Panzer, Milton
Pinsker, L. J.
Sachs, N. J.
Schleimer, M.

Yugoslavia
Marcovic, Prof. M.

EDUCATION

J. H. GARDINER, B.D.S., D.Orth. R.C.S. (Eng.)

Head of the Orthodontic Department, University of Sheffield Dental School

THE word ' Education ' arouses many reactions and memories, some perhaps painful, some pleasant or even expensive, but the word recalls a part of our very existence.

It could also be said that education is the life-blood of a profession, for is not one definition of a profession ' an employment requiring some degree of learning ' ?

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS.

The Report of the Committee appointed by the Council of the Society to consider the teaching of Orthodontics to undergraduates.

MEMBERS OF THE COMMITTEE.

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HAROLD CHAPMAN, L.D.S.Eng., Hon. Dental Surgeon, London Hospital; Examiner in Orthodontics, University of London; Lecturer on Orthodontics, London Hospital Dental School.

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The Committee are indebted to Professor J. C. Brash and Dr. George Northcroft for advice.

Fig. 1.—The Pilbeam Report of 1943 on undergraduate orthodontic teaching.

Our Society has a very special responsibility for orthodontic education. In 1943, under the Chairmanship of Mr. Pilbeam, it produced a report upon the teaching of orthodontics to undergraduates (*Fig.* 1). It is perhaps time that this was now repeated. Also, at the first meeting of the British Society for the Study of Orthodontics in 1908, emphasis was laid on the part this Society could play in postgraduate education.

Postgraduate education in orthodontics has two main facets which may even merge; there is the specialist level, for those who aspire to a postgraduate qualification in orthodontics, and there is orthodontic education, for those in general practice wishing to be able to treat malocclusions or to improve their facility to do this. May we, therefore, look for a moment at the whole dental profession in this country (*Fig.* 2).

If you have the patience to analyse the current *Dentists Register* you will find that about one-quarter of the 17,000 registered have qualified in the past twelve years. My information is that

1957–1968	-	25%
1940–1956	-	40%
Pre 1940	-	35%

Fig. 2.—An analysis of registered dental practitioners.

apart from those who are specialists, it is these 25 per cent of general practitioners who do most of the orthodontic treatment in the General Dental Service. About 40 per cent of those in the *Dentists Register* qualified during the Second World War or during those years of reconstruction immediately afterwards. About another 35 per cent of those on the *Dentists Register* qualified previous to 1940.

These last two groups contain the mature, experienced practitioners, many of whom have a real but often frustrated interest in the orthodontic treatment of their many patients, and you have only to look at the state of the dental curriculum in those days to see why.

UNDERGRADUATE TUITION

Staffing

Some schools were fortunate in the pre-war period in having an adequate orthodontic staff. But some were not. Although there were obvious exceptions, I think that most of us who qualified in those days will agree that orthodontic training then was not as closely supervised as it is today, for now there is an average of more than one part-time member of staff, and *Fig.* 3 shows the state of orthodontic staff in our seventeen dental schools last year. Naturally, the personnel may have changed since that time but, as you can see, the schools do vary in their proportion

Presidential Address presented at the meeting held on 13 October, 1969

of part-time and full-time staff as well as those who are university employed or hospital employed.

Method

As regards the methods of teaching orthodontics to undergraduates each school, no doubt influenced by the curriculum of that school, by the size of its orthodontic teaching staff as well as by the preferences and personality of the teacher, has built up its own system of teaching orthodontics; but I notice that as the years go by there is an increasing degree of similarity developing. For instance, eighteen years ago (Gardiner, 1952) the courses of orthodontic lectures given in our various dental schools are shown in *Fig.* 4 compared with those given in 1968. In these days it seems to be becoming generally accepted that in clinical subjects, now that adequate textbooks are available, lectures are no longer regarded as the main means of communication and instead, tutorial and clinical teaching sessions are increasing as the orthodontic staff increases. Those who have carried out surveys of undergraduate student opinion on this topic of lectures, such as the London Dental Hospital surveys (Flood Page, 1968) may have found this reaction shared by many undergraduates. You may have seen this questionnaire (*Fig.* 5) circulated by the Dental Education Research Unit of the London Dental School to undergraduates attending lectures. This is in accordance with the recommendations of the General Dental Council who in November, 1963, stated of the orthodontic course: ' This should include lectures or demonstrations and clinical instruction in the prevention and treatment of malocclusion as carried out in general practice '.

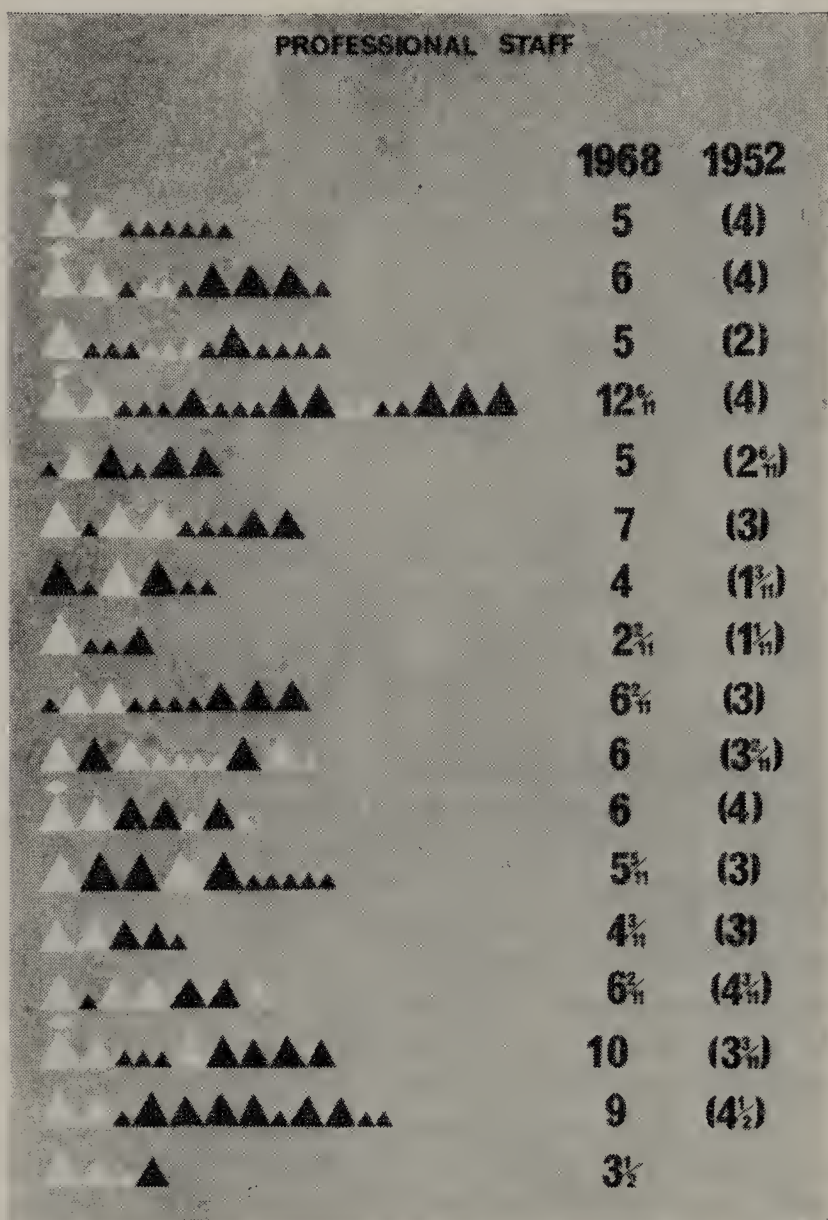


Fig. 3.—Professional orthodontic staff in the seventeen British dental schools. A white triangle indicates university staff (a ' halo ' indicates a professor in orthodontics) and a darker triangle hospital staff. The larger triangles indicate full-time members of staff.

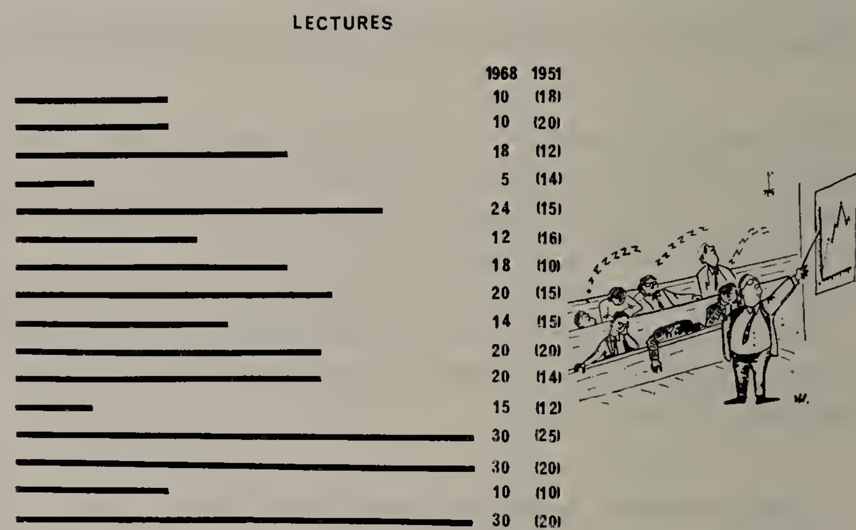


Fig. 4.—The number of lectures in orthodontics at the various British dental schools.

QUESTIONNAIRE ON LECTURE ASSESSMENT

(Please indicate: excessive or good or slight or poor)

SURROUNDINGS ETC.:

Ventilation, temperature, light, seating, extraneous noise, fatigue, hunger.

THE VOICE:

Audibility
Quality
Speed

APPEARANCE AND GROOMING:

MANNER:

RAPPORT WITH CLASS:

AMOUNT OF MATERIAL:

CLARITY AND ORGANIZATION:

STIMULUS AND INTEREST:

SLIDES AND OTHER ILLUSTRATIONS:

Fig. 5.—Example of a questionnaire issued to undergraduate students by an Education Research Unit.

The Lecture and the Lectern

As one cynic pointed out, a lecture can be ' that process by which the contents of the lecturer's textbook are transferred to the note books of his students without them passing through the minds of either! ' In the Middle Ages, when illiteracy was more common, the lecture

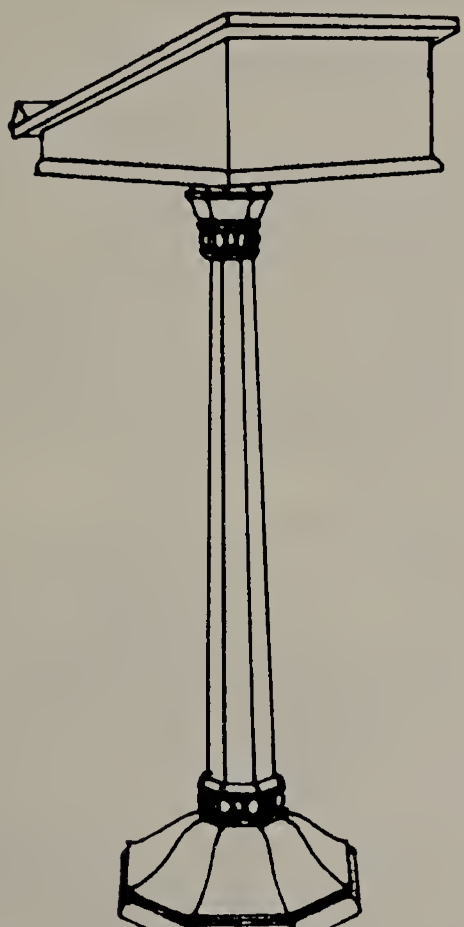


Fig. 6.—Lectern based upon a fourteenth century design. (*With acknowledgement to G. H. Gillam Limited.*)

then was an accepted means of communication. Thompson and Johnson (1937) report that in the thirteenth century, ' In the bare classroom, the master possibly had a desk, but the students sat on the floor with perhaps trusses of straw under them '. Later the universities appear to have become better furnished, but there is one item of furniture in the lecture room which appears to have remained little changed since medieval times, and that is the lectern or reading desk (*Fig.* 6) which is so often based on a design used in some of the more progressive churches of the fourteenth century (Cox, 1923). Also, illumination of the reading surface has changed very little and often consists in the old music-stand type of illumination causing reflection of light backwards from the surface of the lecturer's white notes on to the screen behind him and so reducing the effectiveness, especially of coloured, lantern slide images. The Illuminating Engineering Society in their Report of 1963 on Lecture Theatres recommended screening the reading light rather as in the lectern shown in *Fig.* 7 so that the lecture notes are contained in a well with a wooden overhang requiring only low-powered bulbs and the amount of light scatter is accordingly reduced.

Voice Reinforcement

As regards the spoken delivery of a lecture, I suppose most lecturers have secretly entertained the opinion that their melodious bass-baritone had the carrying power of a small fog-horn, but this opinion is not necessarily shared by their listeners; in addition, the architectural acoustic

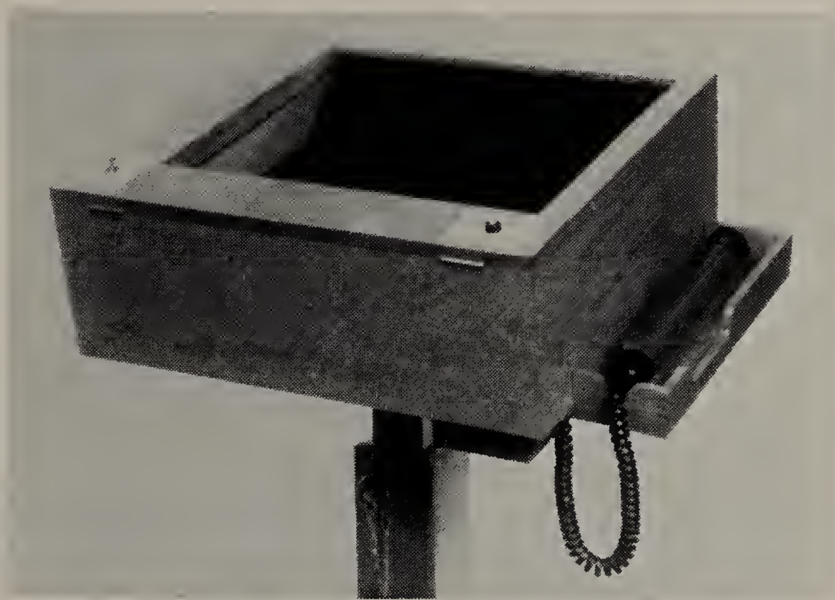


Fig. 7.—Example of a non-glare lecture reading desk.

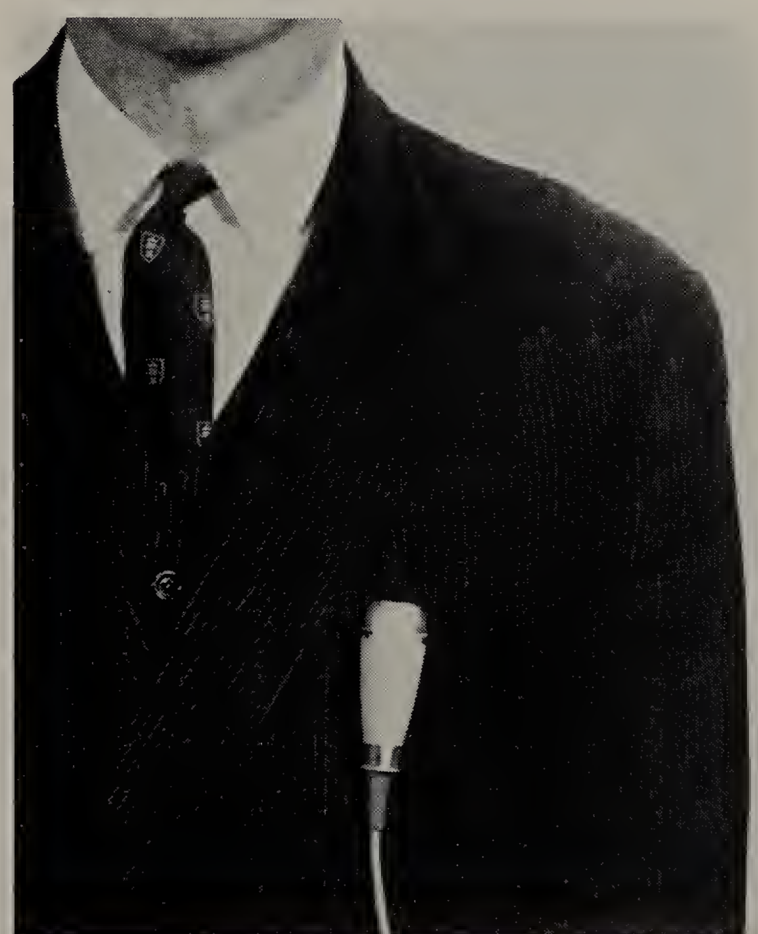


Fig. 8.—A modern lavalier-type clip-on microphone suitable for a lecturer.

design of many of our lecture theatres does not always compare with modern standards (Duncan, 1966). Naturally, in previous years one was limited to one's natural resources, but in these days of electronic aids, voice reinforcement is becoming increasingly accepted, and as many as four dozen loudspeakers can be placed in a lecture theatre. Experts in this field who advise upon the design of many of our modern lecture

theatres, recommend a halter-type or clip-on microphone (*Fig.* 8) in preference to the older, stand type of microphone, for unlike the latter a lapel-mounted microphone would follow the lecturer as he turns round to the screen and there is no falling off in voice reproduction. The amplifier in the modern 16-mm. cine projector, which features in most lecture halls can be used,

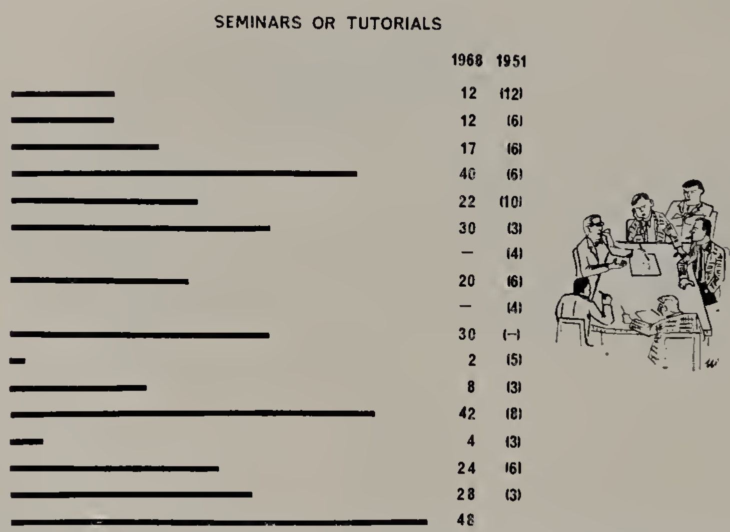


Fig. 9.—The number of seminars in orthodontics given at British dental schools.

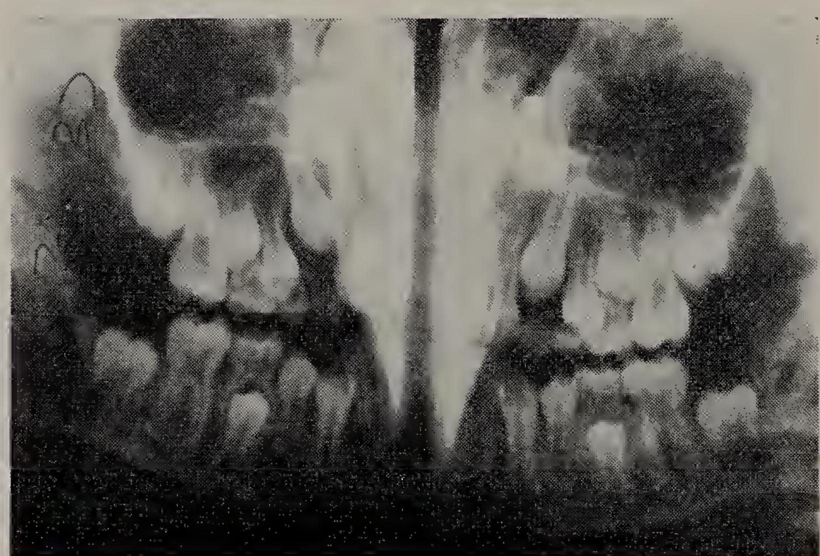


Fig. 11.—Oblique lateral orthodontic X-ray view.

if necessary, in the microphone circuit. Yet a further refinement is, of course, the radio-microphone, which transmits to a receiver and so does away with any trailing leads.

Seminars

Another way in which orthodontic undergraduate tuition is given is through seminars or discussion groups (*Fig.* 9) outside the clinic, in which one student prepares a subject for presentation to the class (Iyer, 1964). These vary from school to school, but certainly they do have the effect of not only bringing the teacher into closer touch with his students, but they can produce some material of surprising quality from the most unexpected students, who, quite unconsciously in this way, get training in the oral presentation of facts. As you probably noted in the earlier figure, some dental schools are reducing the number of their lectures but increasing the seminars.

Chairside Teaching

Although most time-consuming of all for the staff, it is undoubtedly the chairside teaching session (*Fig.* 10) where the student is brought most closely into touch with orthodontic diagnosis and treatment planning. This also varies from dental school to dental school. These may be observational-instructional sessions where the

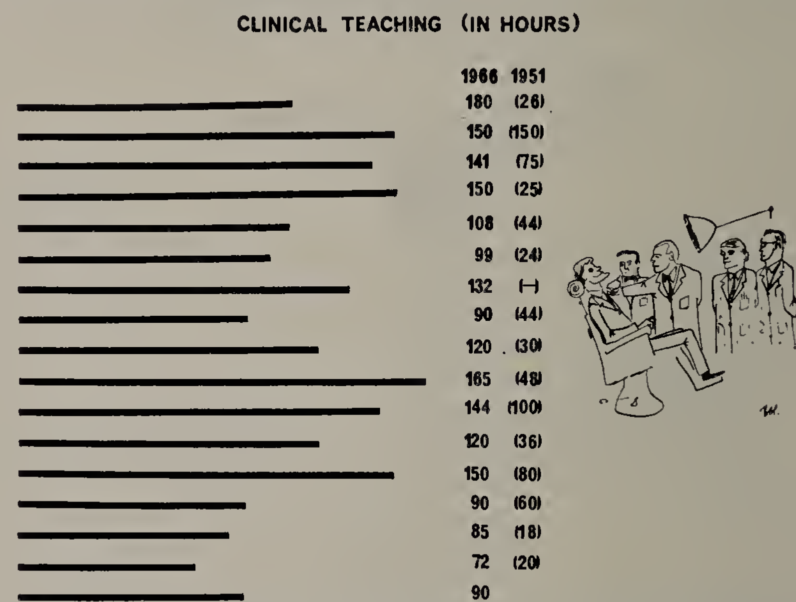


Fig. 10.—Clinical teaching (expressed in hours) of undergraduate orthodontics at British dental schools.

teacher demonstrates diagnosis, aetiology, or treatment, or those sessions where one student presents to the rest of the class a patient he has previously examined. As regards numbers, 3–4 is ideal but, as recommended by McEwen (1964), they should not exceed 5.

Radiographs

An important aspect of clinical teaching is the information conveyed by radiographs. In this respect we probably demand a wider view of the dentition than most other dental hospital departments. The old favourite in orthodontic diagnosis is the oblique lateral view (*Fig.* 11) of the posterior teeth and with the anterior occlusal views covering the anterior teeth, an almost panoramic view of the dentition is given (Gould, 1968). For years this X-ray view has been known amongst orthodontists as the ‘rotated lateral oblique’ view but, as an experienced dental radiologist pointed out, when viewing the patient from the lateral aspect, one has a true lateral view and an oblique lateral view, it is not an oblique view taken laterally! The oblique lateral views do, however, require a measure of skill in their taking unless some form of head support is used (*Fig.* 12), and undoubtedly, this is the X-ray view we must train undergraduates to use. For teaching purposes, however, the various panoramic X-ray machines now available give an excellent view of the whole dentition clearly visible to a class even 10 feet away from a viewing screen. *Fig.* 13 shows a radiograph taken with the Orthopantomograph Mark II machine.

A minimum of radiation is given, due to the narrowness of the beam (*Fig.* 14), in fact the dosage on the tongue is about that of one intra-oral film.

Undergraduate Treatments

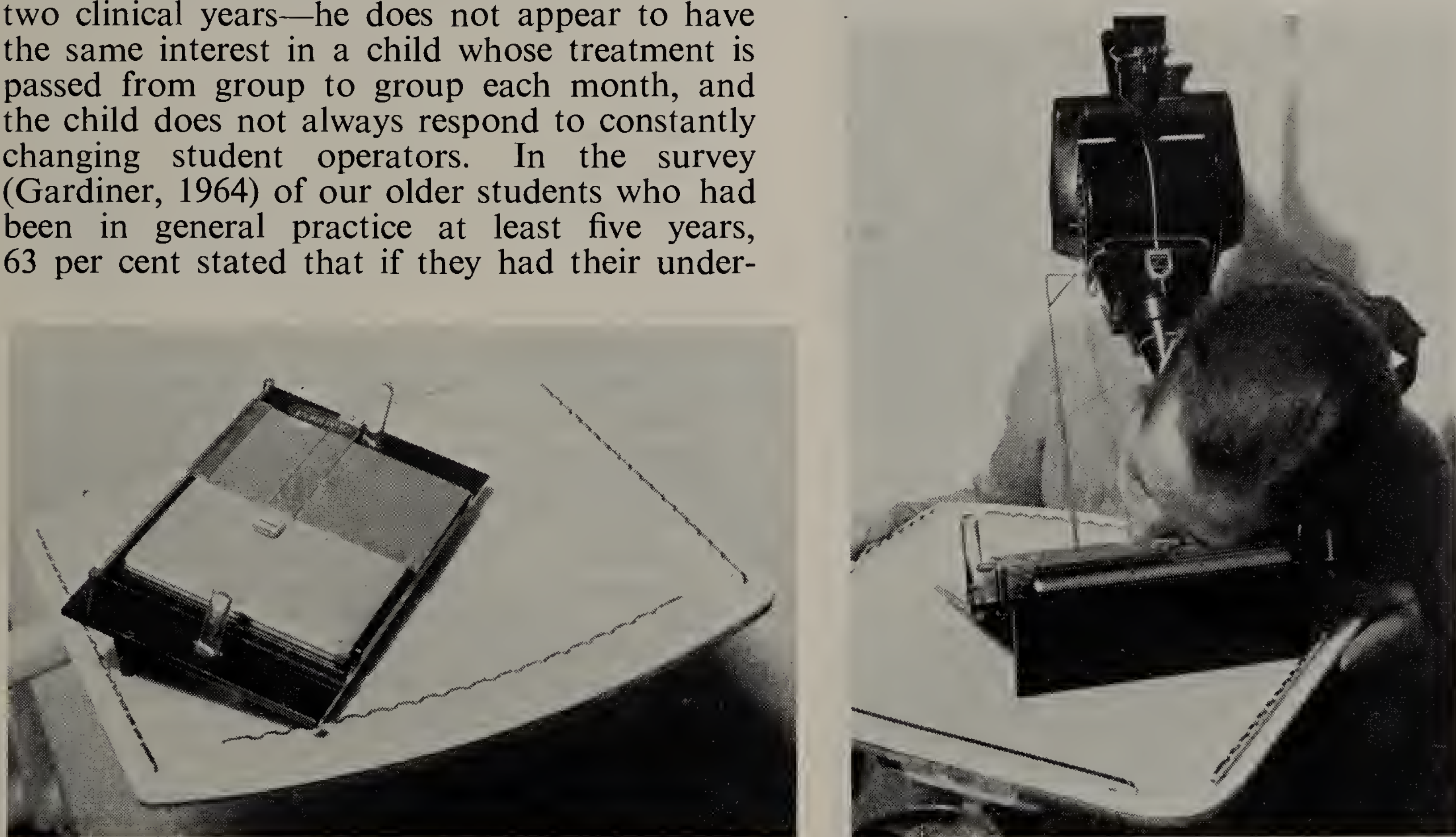
The student, however, does learn most from himself treating selected patients under observation, and three would seem to be the favoured number among the various schools (*Fig.* 15). It is found, also, that the student learns more from treating the same patients continuously over his two clinical years—he does not appear to have the same interest in a child whose treatment is passed from group to group each month, and the child does not always respond to constantly changing student operators. In the survey (Gardiner, 1964) of our older students who had been in general practice at least five years, 63 per cent stated that if they had their undergraduate orthodontic course over again they would prefer to treat more patients under supervision, as this would prepare them more adequately for giving treatment in general practice. A fact not always appreciated by authority is that most practitioners giving orthodontic treatment today rely almost entirely upon their undergraduate training in this subject, so it is logical to assume that an improvement in undergraduate tuition would be reflected in the quality of the treatment given in general practice.

Technique Course

In order to train students in the manipulation of hard stainless-steel wire, nearly all schools give a course in orthodontic technique usually in the pre-clinical period (*Fig.* 16).

Audio-visual Aids

It is a most salutary exercise with past students to ascertain just how effective one's undergraduate



A B

Fig. 12.—A, A head-positioner arranged for a left oblique X-ray view. B, Patient and antenna parallel to the central beam.

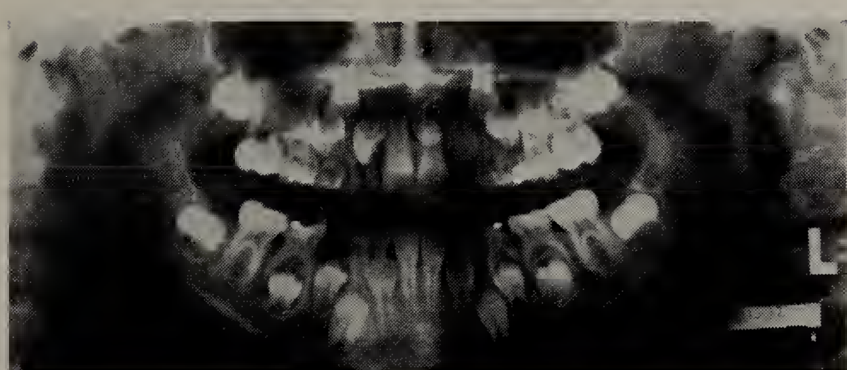


Fig. 13.—Radiograph of a 7-year-old child taken with a Seimens Orthopantomograph machine.

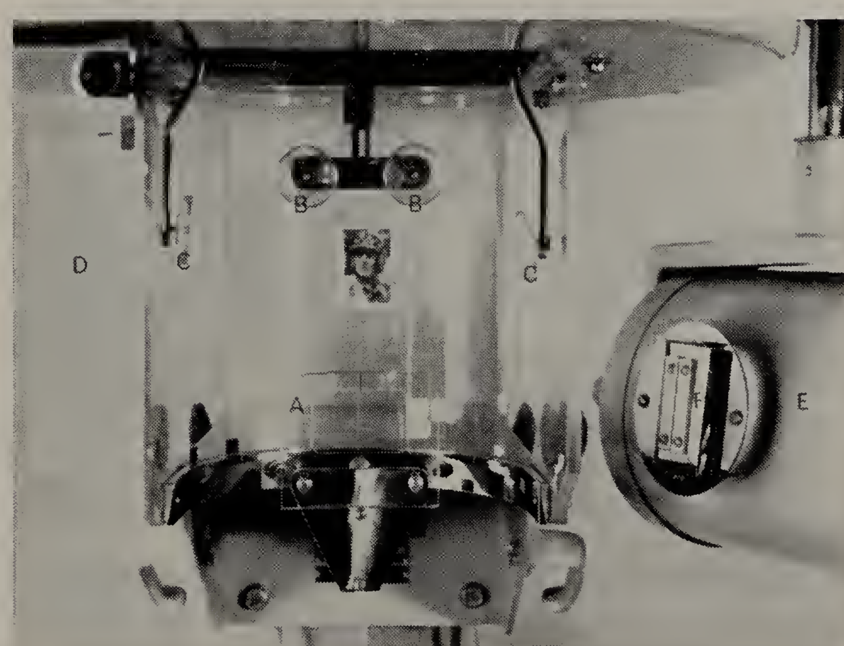


Fig. 14.—Close-up view of the Orthopantomograph showing: A, Chin rest; B, Forehead rests; C, Pads applied to the temporal areas; D, Site of film holder; E, X-ray tube housing; F, Collimator with slot 1 mm. × 30 mm. through which the X-ray beam emerges.

teaching course has been (Gardiner, 1964). Possibly also the Dental Estimate Board must be in a good position to assess the performance in actual practice of our old students. The question uppermost in the minds of most teachers and instructors is ' how do you get such a curriculum across in the best possible manner, in the minimum of time, and with the absolute minimum of staff? ' One further complication about to arise is that the Government may demand an increase in the annual intake of students without any corresponding increase in staff! What does one do?—does one lower the level of teaching, or does one make use of the teaching aids now being developed in order to distribute effectively the experience and knowledge of especially the senior clinical staff?

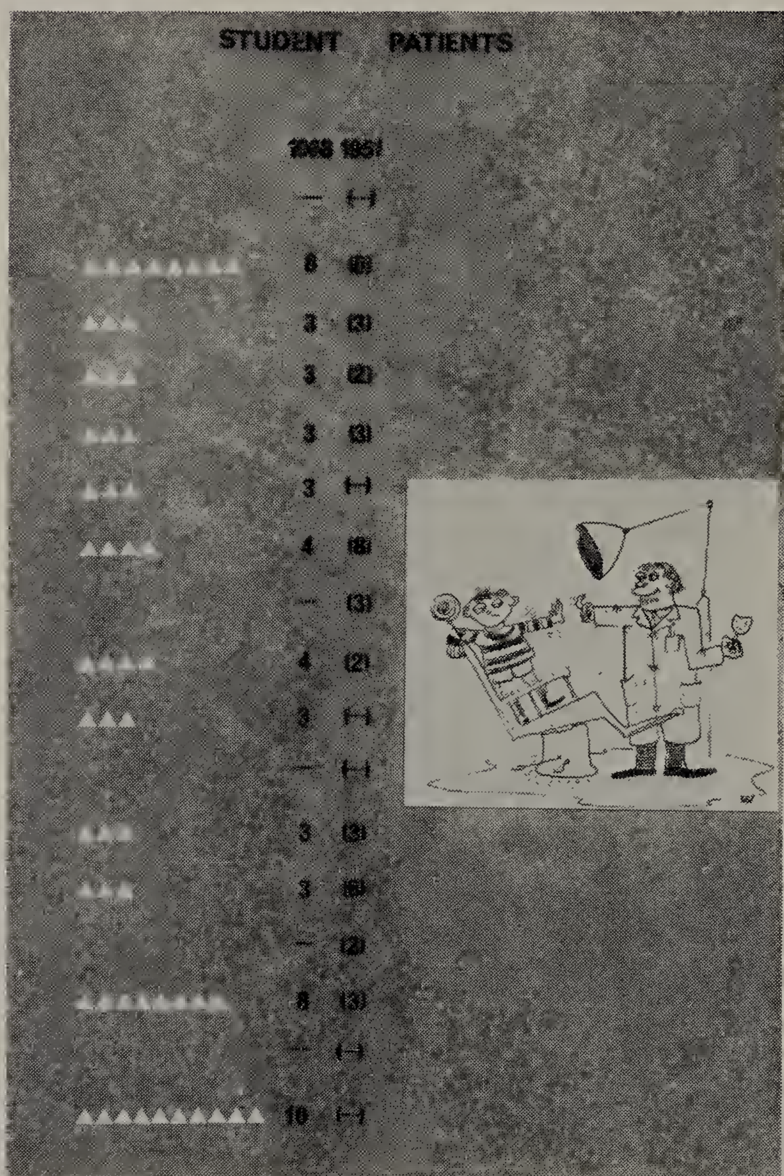


Fig. 15.—Patients treated by undergraduate students at British dental schools.

When first one hears of audio-visual aids, one seems to react in one of two ways:—

1. Either, one dismisses them as gimmicks to be used only by cranks or those with more time to spare than oneself, or

2. One is tempted to think that if one had enough pre-prepared material on magnetic tape or celluloid, then one could put one's feet up or get on with important research projects and leave the students to be processed by mechanical means!

In fact the truth would appear to lie between these two illusions and, despite the pressures to produce more papers, more research, etc., one may get the uncomfortable feeling that one's own traditional methods of teaching might be improved by a consideration of these new-fangled ideas!

Having used some of these audio-visual aids one is bound, sooner or later, to admit that they have to be used wisely to supplement, rather than to replace entirely, our more traditional teaching methods.

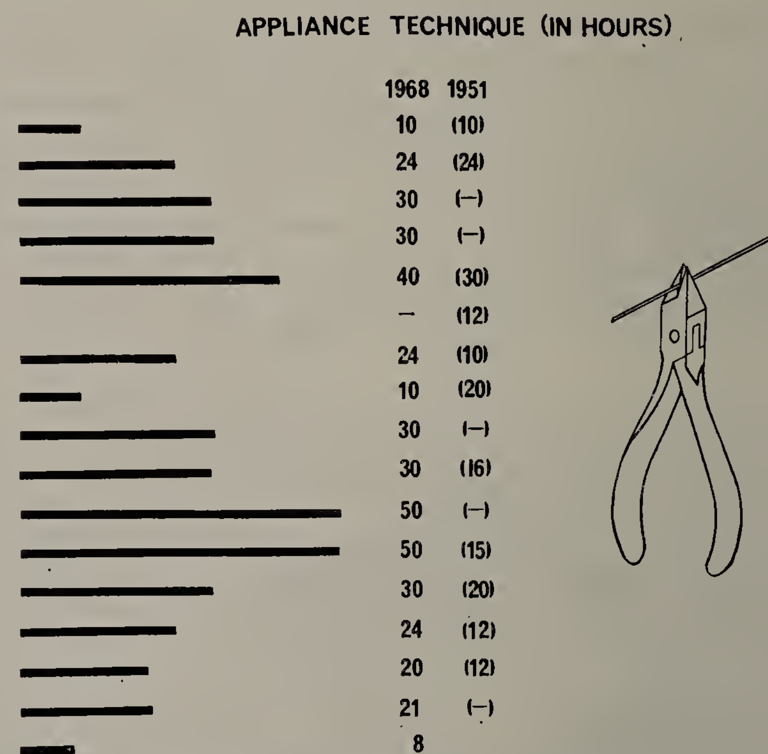


Fig. 16.—Appliance technique courses (expressed in hours) at British dental schools.

In more recent years, colour photographic transparencies have become increasingly popular and most of us in teaching hospitals have a large number of these showing patient conditions, but, all too frequently, these beautiful transparencies remained filed away! There are now various ways in which the information contained in those transparencies can be communicated to students. Some clinical teachers, such as Illingworth (1965), have duplicated many of their slides, interposed between these suitable title slides and arranged them in magazines so that a student can, at any time, go through such a series, by placing the magazine of slides in a projector preferably fitted with some type of day-light back-projection screen.

A further development of this idea, which utilizes the sense of hearing in addition to that of sight, is through a tape recorder, using a commentary on an accompanying magnetic tape which, at intervals, instructs the student to change over the slide. Harden, Wayne, and Donald (1968) of Glasgow have done much work on the use of this method in clinical teaching and exchanges of information in this way are becoming increasingly

popular. For some years the American Dental Association, for instance, has put out a series of tape-slide sequences for the use of those in general practice. In this country, the work of Dr. John and Dr. Valerie Graves (1967) in the Royal College of General Practitioners is now widely acknowledged and Regional Hospital Postgraduate Centres are establishing central libraries of slides and tapes based upon the actual lectures of national authorities; these are posted to registrars studying in the more remote hospitals.

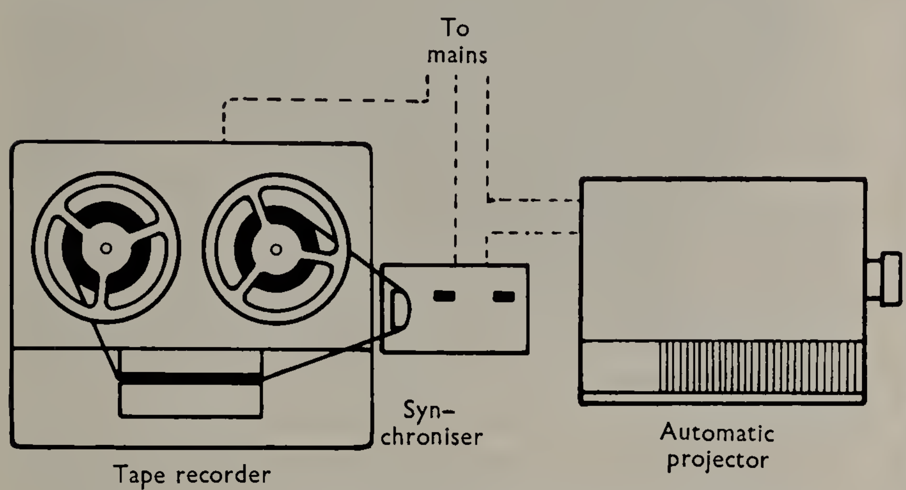


Fig. 17.—Combination of automatic projector, synchronizer, and tape-recorder when playing a tape-slide sequence.

Synchronized Tape-slide Projections

Yet a further development of this idea which has been in use for some years is to connect the tape recorder to the projector through a synchronizer (*Fig.* 17). The upper track of the magnetic tape carries the spoken commentary and the lower track a sub-auditory signal which, at a pre-arranged point in the commentary, will activate the slide change mechanism in order to bring the next picture on to the screen. Such an apparatus was arranged by Price (1968) at the Sheffield Dental Hospital using an old hospital trolley to make it portable (*Fig.* 18). Gagné and Fleishman (1959), in their book *Psychology and Human Performance*, claim that any process involving the learning of a skill can be taught most effectively this way, and in one American Dental School, Starkey and Doehring (1964) found encouraging results could be obtained following the use of automated slide projectors with synchronized tape recorders in the teaching of dental techniques. Not only did the students so instructed score excellent marks, but there was also a saving in instructor manpower.

In recent years we have been conducting experiments at the Sheffield University Dental School in which a class of thirty undergraduate clinical students have been divided by the University Department of Education into two groups of equal ability. The control group was taught by instructors using traditional methods, and the other group, the experimental group, was taught by a magnetic tape commentary with lantern slide illustrations. Students in both groups had to perform identical tasks which, in this instance, was tracing the various points shown on identical cephalometric X-ray views of the skull (*Fig.* 18). Subsequently both groups

Fig. 18.—A synchronized tape-slide programme instructing a student in cephalometric tracing.

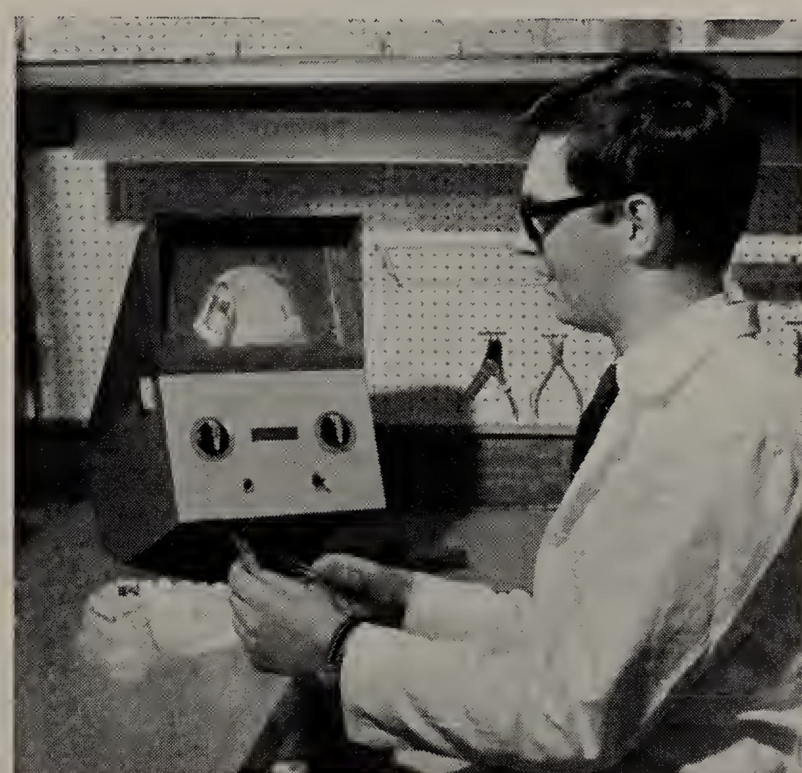
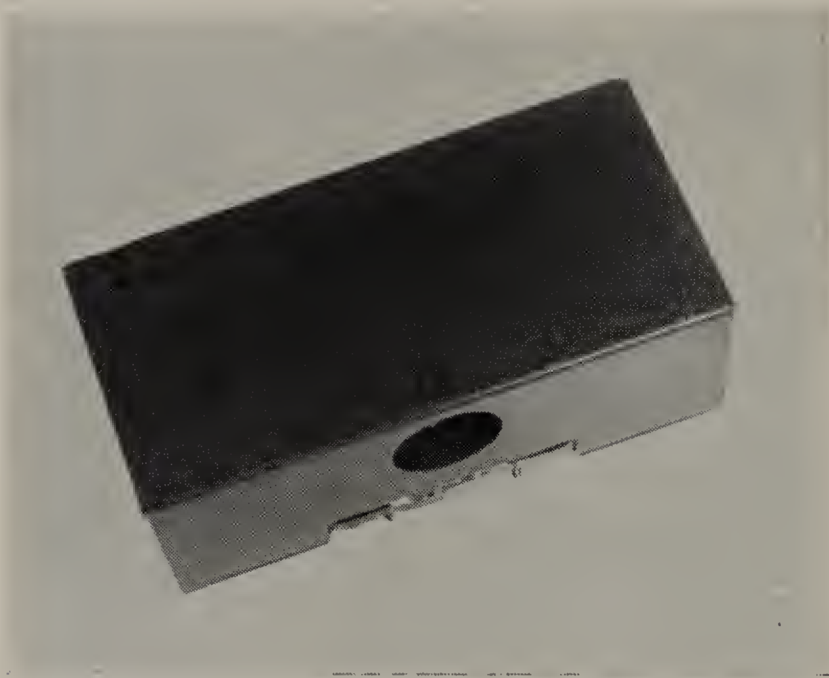


Fig. 19.—Student following a technical procedure on a Mk I Plessey ' SuperVisor ' which uses a 35-mm. film strip and magnetic tape commentary enclosed in a cassette.

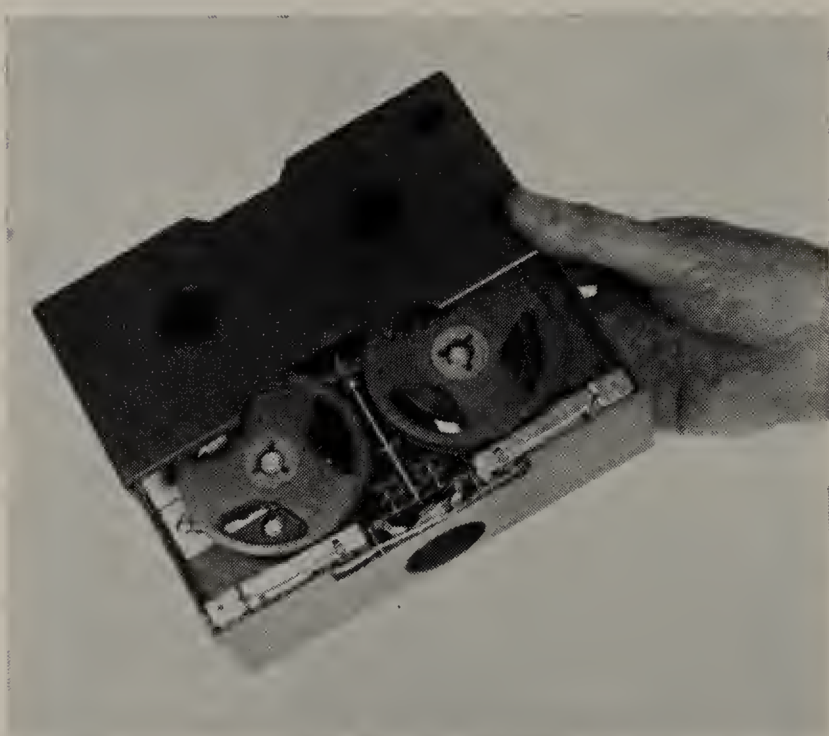
sat a short written test and their tracing are being compared with a template.

A more sophisticated version of this principle has been developed by the Plessey Corporation in their ' SuperVisor ' machine (*Fig.* 19) which has the advantage of the lantern slides being in film-strip form and enclosed in a plastic cassette (*Fig.* 20). Those who have seen or used the original

manually operated Mark I version of this machine, may like to know that a division of the Plessey Corporation are now introducing a Mark IV version, which can operate either with an



A



C

automatic change-over of the picture in accordance with the signal on the second track of the tape or, by the flick of a switch, be manually controlled. It is found that the slower student and those experiencing language difficulties, much prefer this type of machine because it saves the embarrassment of them repeatedly visiting a demonstrator who may or may not be sympathetic.

Stereo-photography

Those with an eye for perfection, may prefer to use stereo-photography. Although the idea goes back to 1841, Clemetson (1957), lately of the East Grinstead Photographic Department, has developed, to a very fine art, intra-oral stereo-photography, by using a special twin-lens attachment on a 35-mm. camera.

8-*mm. Cine Films*

Where a dynamic process requires to be demonstrated to a small audience, cine films may have advantages and you have probably seen the

B

Fig. 20.—A, Plastic cassette for a Plessey 'SuperVisor'. B, Cassette opened to show 35-mm. film strip. C, Under-surface of opened cassette showing the spools of magnetic tape.

8-mm. films pioneered by Leighton and Warner (1957), Liddelow (1962) and others in the clinical field. For viewing these 8-mm. cine films a rear-projector, such as the Fairchild Mark IV, may be preferred by the student (*Fig.* 21) since this machine is small, portable, and also carries a sound track. It has been used in America since 1961 so is a well-tried teaching aid.

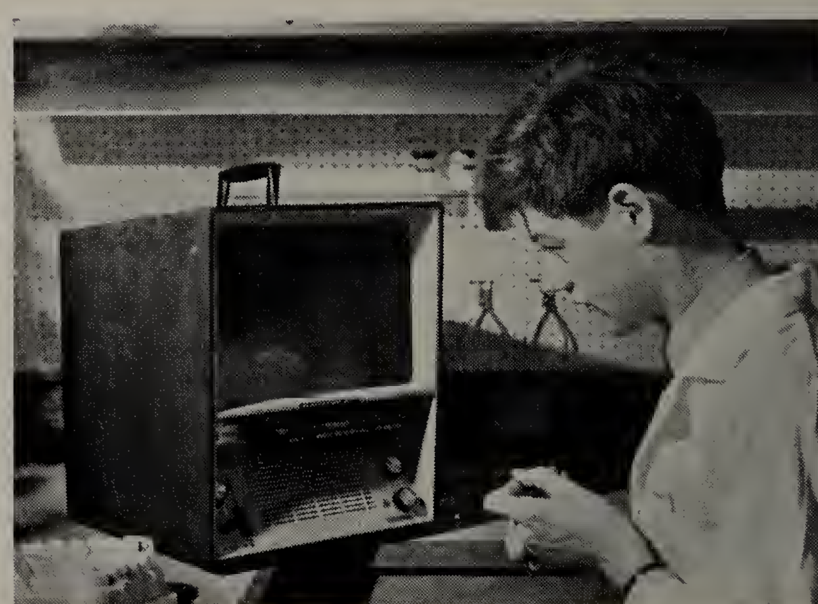


Fig. 21.—In this Fairchild Mk IV 8-mm. cine viewer the sound is reproduced from magnetic edge-striping on the film which is enclosed in a cassette.

16-*mm. Cine Projections*

For larger audiences there is the 16-mm. cine film projected on to a screen. Nowadays cine projection is not the labour it used to be for

automatic self-threading projectors are available and all one has to do is to switch on, place the end of the film through a slot, and the film is automatically threaded through the gate at the right tension and merely requires connecting on to the take-up spool. A built-in loudspeaker gives adequate sound reproduction in a small room.

As regards the effectiveness of this cine film method, I feel this needs further investigation especially in the field of clinical teaching.

Closed-circuit Television and Electronic Video Recording

In addition to tape/slide and cine film systems there is closed-circuit television and, for the future, electronic video recording in which, on a domestic television viewer, a complete television programme can be played from quite a small cassette. But possibly these are early days to be considering such, as yet, highly expensive pieces of apparatus. Perhaps, too, when they become available in an inexpensive colour version, then television may enter more into clinical teaching.

Assessment of Teaching Aids

These are but a few of the many teaching aids now available but, as you will probably realize, they have to be used with discretion. Even in this machine age students are still human beings and still require human attention, so although audio-visual aids can be used to extend, to emphasize, and to supplement human teaching, they can never completely replace it.

Production of Teaching Aids

The wiser among you, who have already had experience of these teaching aids, know that they are not produced without a certain amount of time, effort, and thought, and you may be tempted to wait for others to do the producing. There may be around some confirmed individualists like myself, who used to claim that ' too many cooks spoil the broth ', but I now have to admit that whether it be a textbook, or a film it is always better for the opinions of others. Obviously one man has to initiate the process but that first effort is limited to his own thought and experience, and especially on a teaching project, it may not be acceptable to other teachers. Film-producing firms are well aware of this and are loath to sponsor any film which shows a highly individualistic technique of a very limited appeal to a profession. There is need, therefore, to exchange and circulate our teaching productions with as many colleagues as possible. For instance, when making a film of radiological technique, we found it of considerable help to circulate a series of thirty still lantern slides with a written commentary, among about fifteen experienced colleagues who, at that stage in the project, were able to offer advice and suggestions in the presentation of the technique and the terminology used. With the aid of an ' Illumitran ' copying machine (*Fig.* 22), it is now possible for 35-mm. transparencies to be copied quite accurately and quickly and even improved in the process. Certainly, it has been our experience that through these interchanges between the various teaching centres, not only do ideas become clarified but

Fig. 22.—' Illumitran ' machine for copying 35-mm. transparencies and making film strips.

also the aids are improved and the part they can play in teaching becomes better appreciated.

As regards the development of these aids, undoubtedly, of course, it requires a good script from ourselves, but above all a good photographer and preferably one with a training in presentation. Possibly, also, it requires some understanding between the various teaching centres, because, for instance, there is no point in all eighteen Dental Schools and other Teaching Centres in this land making erudite presentations upon the same subject, but each School and each centre has its own special interests and with some co-operation it should be possible for a large number of presentations, all on different subjects, to be made so that they could be used by all Schools. But could not the B.S.S.O. become that independent co-ordinating body so that the benefit of the knowledge, skill, and experience of the few can be made more fully available to an increasing number of students and practitioners?

GENERAL PRACTITIONER TRAINING

There must be many who have given or taken part in general practitioner orthodontic refresher courses. I would be most interested to know your experiences and the results of any follow-up surveys to determine the effectiveness of the various types of course. Certainly, such courses can be most rewarding (Gardiner, 1966) and possibility exemplify this old Chinese proverb (*Fig.* 23). If you remember 75 per cent of those on our *Dentists Register* qualified before 1956 (*Fig.* 2) when undergraduate orthodontic teaching staff was becoming more adequate in most dental schools and yet less than half of the dental surgeons in general practice provide any orthodontic treatment; so there should be plenty of scope for those wishing to give general practitioner refresher courses.

给予一魚，够吃一天，
教以垂鈎，足食一世。

Fig. 23.—Old Chinese proverb: ' Give a man a fish and you feed him for a day. Teach a man how to fish and you feed him for a lifetime '.

Most will probably agree that isolated postgraduate lectures on orthodontics just by themselves may raise a passing awareness, but do little to improve the standard of orthodontic practice in the General Dental Service. Quite apart from deficiencies in clinical knowledge and practice, a common cause of much orthodontic failure is the low standard of appliances produced through inexpert design and bad construction. Thus, in any refresher courses it is an advantage if these can be designed in parallel so that both the practitioner and the technician normally constructing his orthodontic appliances can take part simultaneously (Gardiner, 1967). When technique and clinical courses were held quite separately and at different times it was possible for the dental surgeon to be trained in appliance therapy but, on return to his practice, be unable to find appliances constructed to the desired standard. Alternatively one can appreciate the frustration of the keen dental technician who, after training in appliance technique can find no outlet for his skill because his dental surgeon does not practice orthodontic therapy!

Resistance to postgraduate refresher courses comes from not only the practitioner who feels he is too old to learn new tricks but also the practitioner who is content with the service he gives his patients. On the instructional side opposition can come from the teacher who feels he is under pressure to produce papers and theses and therefore cannot devote the time to preparing and running such courses. I know only too well the temptation to remain in a hospital centre and not to get involved in the needs of our profession, but never let it be said of us that we ' stay in our offices with our brains bulging and never get out to the country '.

From the viewpoint of staff time, the smaller courses for one or two practitioners are much less demanding, for they need the minimum of preparation and can be absorbed into the working of the department.

Some years ago at the conclusion of another general practitioner refresher course, a practitioner, whilst expressing his appreciation for the tuition received, said that no matter how excellent the refresher course, it could only serve as an hors-d'oeuvre, so could not the course arrange to meet regularly in the future in order to maintain contact and receive further tuition? The other practitioners in the course, whilst congratulating him on his idea, promptly elected him as Chairman of the future Orthodontic Study Group, and as this took place in Yorkshire, the next official to be appointed was the Treasurer, who immediately passed the hat round for ten shillings a head! Three months later the first meeting was held at which it was proposed to use the first subscriptions to circulate all practitioners in the region, with the result that under the guidance of a very able and devoted Committee, the Study Group grew from twenty in the first meeting to over one hundred a year later. I understand that this is how our own B.S.S.O. and many other Societies have developed.

It would seem that there are now about twelve known Orthodontic Study Groups in various parts of the country, with others that are forming or about to be formed. They certainly deserve every encouragement. Possibly one way in which this Society could help is by holding occasional regional meetings and, as in the Institute of Electrical Engineers, encouraging lecturers to duplicate their lecture if so requested in another part of the country.

CONCLUSION

It may have seemed an impertinence to think of covering the tremendous field of orthodontic education in a single paper, so I hope this will be regarded more as a contribution. The future chapters will be produced I am sure, not by any individual but by all of us interested in raising the standard of orthodontics in this country.

[After the paper demonstrations were presented upon the Plessey SuperVisor (T. Johnson), the Illumitran (R. Cousins), synchronized tape-slide equipment (C. J. Minors), self-threading 16-mm. cine projectors (J. F. V. Larway), and stereo-photography (D. F. Glass).]

Acknowledgements

I would like to thank my many friends in the fascinating fields of education and photography for their help and interest. Also I wish to record the help received from the University of Sheffield Dental Research Fund in the development and application of teaching aids and from Miss E. M. Williams, of the Department of Education, in the planning of teaching experiments. My thanks are also due to Mr. R. Cousins of the Sheffield Dental Hospital Photographic Department for the illustrations.

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VOTE OF THANKS

Mr. W. A. B. Brown, in proposing a vote of thanks, said that he thought the President had identified some of the different ways that orthodontists could contribute to the future of their profession. He had shown more than anything else how, in the field of education, they were all united in their aims. Their ultimate objective was to improve the lot of their patients. By a review of the improved techniques that were now available for communicating the word of the orthodontist he had shown that we were embarking on a new era. Mr. Gardiner and his demonstrators had given everyone an opportunity of seeing how orthodontists could achieve some of the objectives he had outlined. For this everyone was truly grateful.

He concluded by saying that it gave him very great pleasure to propose this vote of thanks on behalf of the members and guests.

The vote of thanks was carried with acclamation.

LONG-TERM RESULTS OF MANDIBULAR OSTEOTOMY: AN INTERIM REPORT ON THE TREATMENT OF YOUNG SUBJECTS

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THE following report is concerned with the results achieved following the correction of mandibular prognathism in six young subjects whose ages ranged between 8 and 10 years. The period of review varies from 3 to 6½ years after surgery. A brief report will also be given of three older subjects who had surgery for the same condition at 12 or 14 years of age. The longest period of postoperative observation in these cases has been 4 years.

There always has been, and still is, a resistance to early osteotomy, but very little appears to have been published in opposition to the procedure. Goldstein (1947) reported two cases, one of whom had two unsuccessful osteotomies within the space of 4 years. Relapse was attributed to an excessive spurt of mandibular growth associated with the age of the subjects, but it is considered that other causes could be found, particularly in connexion with the type of surgery employed. Biederman (1960) has also concluded that the reason for relapse was to be found in the operative technique used and not in the age at operation. In the cases reviewed by Goldstein, the operative technique was the blind Gigli-saw osteotomy—a procedure to be condemned.

GROWTH AND DEVELOPMENT IN RELATION TO EARLY SURGERY

Growth Spurts

Investigations of the growth process in a large sample of young subjects usually leads to the discovery of spurts of growth between the ages of 9 and 13 in females and 11 and 17 in males, when the mean figures are considered. The effect of such periods of rapid growth will not be necessarily confined to any one part of the body such as the mandible. Atherton and Wynne (1964) found no evidence of excessive mandibular growth in Class III cases, comparing them with Class I and Class II, division 1 cases over a period of 10 years covering the time between 10 years of age and adulthood. Maj (1968) found that spurts of growth in either the ramus or the body of the mandible could occur at any age, and he concluded that mandibular growth is unpredictable and that spurts can occur at any time in individuals. He also found that his mean figures came within the same age range as those found by other investigators.

Adolescent Lower-face Prognathism

The development of a mandibular basal prognathism is a well-known phenomenon shown in the investigations of Björk (1951) and Lande (1952). It is not necessarily so that this will develop excessively in cases of mandibular prognathism unless there is a frank condylar hyperplasia, Goldstein (1936) found that face length was the dimension most clearly affected by the adolescent growth spurt. Therefore, those cases of prognathism associated with an anterior open bite will be those in whom future growth will have the greatest relapsing potential, particularly when the correction of the anterior open bite is concerned. The subject with the more normal mandibular-maxillary (M.M.) angle will have less vertical growth component than the one with the larger M.M. angle. In neither of them will the amount of growth necessarily be any greater in amount—it is the growth direction that is the more important in its effect. One must also bear in mind that all dimensions will be larger in the adult with the effect that any reversal of the overjet present in the child will be increased in proportion with other facial dimensions. In any case, the development of the mental prominence is an important factor in forming lower face prognathism without there being any great increase in dental prognathism.

The Decision to Carry Out Early Corrective Surgery

The following factors were taken into consideration when it was decided that early corrective surgery might be offered to some cases of mandibular prognathism:—

Presented at the meeting held on 10 November, 1969.

1. Unsuitable surgical procedures used in the past may well have been responsible for the relapses that occurred.

2. Some young prognathics may not have been suitable subjects for osteotomy.

3. The findings of Atherton and Wynne (1964) have already been referred to, and Lande (1952) has stated, following his study of the growth behaviour of the bony facial profile, that ' The findings indicated that most cases in this study, regardless of differences in type, showed the same general tendencies in their growth behaviour '. Most Class III malocclusions could, therefore, be regarded as congenital differences in jaw size in which the disproportion will remain essentially unaltered during the growing period. There would seem no reason, therefore, why an anatomical disproportion could not be altered at any age.

4. In all the cases reported, there was genuine embarrassment with the appearance, which occasioned unkind remarks from their schoolfellows. In a child, this would seem reason enough to change their outward appearance for the better.

5. If normal anatomical function of the teeth can be established during the surface appositional growing period of the middle face, then at least as far as the maxillary alveolar process is concerned, a more normal pattern of appositional growth should occur—the optimum growth potential can be achieved. Since by the nature of the appositional growth of the maxilla, what was early alveolar process becomes incorporated in the apical base region, then this area will be given the possibility of achieving its optimum growth potential also.

6. A speech defect is often present due to the relatively forward position of the anterior attachment of the tongue associated with the prognathism. An early correction will offer the more correct anatomical basis for the establishment of normal speech.

THE CHOICE OF PATIENT

1. The principal requirement is that there should be a deep overbite present. No young subject with an anterior open bite or a very small overbite has been chosen for early osteotomy. The elimination of those with an anterior open bite or a very small overbite will also exclude those with the larger M.M. angles, who, it has been pointed out, are likely to have more tendency to relapse because of their growth pattern.

2. Care must be taken to avoid a pseudo-Class III malocclusion in which mesial guidance is present. Biederman (1967) has described a useful clinical aid in helping to identify the presence of this condition. If facets are found to be worn upon the lower labial aspect of the upper incisors then a forward posture of the mandible is likely to be present. Such patients can also usually achieve edge-to-edge incisor occlusion and this possibility must be investigated. It would obviously be disastrous to carry out an osteotomy upon such a case.

3. None of the cases chosen exhibited evidence of overclosure, which would, if present, exaggerate an otherwise mild Class III condition. This condition is more usually associated with a reduced maxilla and middle third of the face

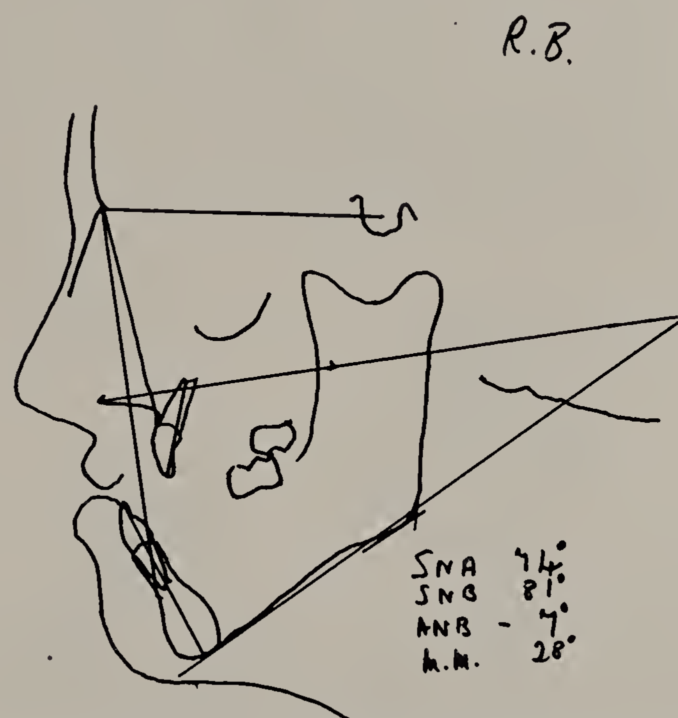

Fig. 1.—*Case R.B.* Crouzon's syndrome. Note the depression of the middle third of the face.

rather than with a mandibular excess. A large free-way space is usually present, but the subject will be found to have a good profile in the rest position and only a prognathic appearance in occlusion, when, in fact, they will be overclosed. A combination of clinical and cephalometric examinations will help to identify such cases, but sometimes it is found that clinical and cephalometric impressions do not correspond.

Cephalometric Investigations

Tracings taken from headplates of some patients who have been referred for osteotomy will be used to illustrate some aspects of the differential diagnosis of those who have a Class III malocclusion but who, for various reasons, may not be suitable for treatment by mandibular osteotomy. *Fig.* 1 illustrates an example of severe depression of the middle third of the face. Further enquiry gave a history of craniosynostosis, and Crouzon's syndrome was diagnosed. The value for SNA is very small compared with the mean of 81° found by Mills (1966) in his control series. SNB is somewhat larger than the mean for the same series (78°) but, nevertheless, the greater anomaly can be seen to be in the middle third of the face. It would be obviously wrong to resect the mandible in such a case;

instead, the middle third of the face should be advanced after the manner of Tessier (1967) and Murray and Swanson (1968).

The tracing of the child shown in *Fig.* 2 poses a more difficult problem. Although she appeared to suffer from a depression of the middle third of the face upon clinical examination, it may be seen from the tracing that her SNA is of the mean value (Mills), whereas SNB is considerably over the mean value of 78°. The film used was taken in the rest position. Some overclosure was present partly due to the delayed eruption of the cheek teeth. Clinically it would not seem advisable to carry out a mandibular osteotomy, yet a decision based upon the cephalometric measurements would be in favour of such a procedure. Investigation into her past revealed a history of idiopathic infantile hypercalcaemia.

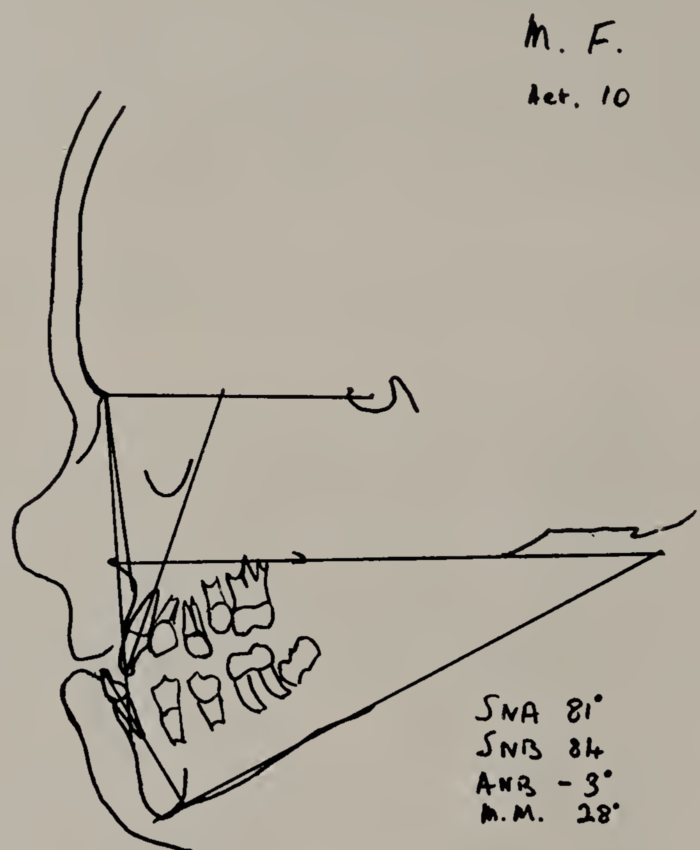

Fig. 2.—*Case M.F.* Idiopathic infantile hypercalcaemia. Clinically a middle third facial recession, but cephalometrically would seem suitable for mandibular osteotomy.

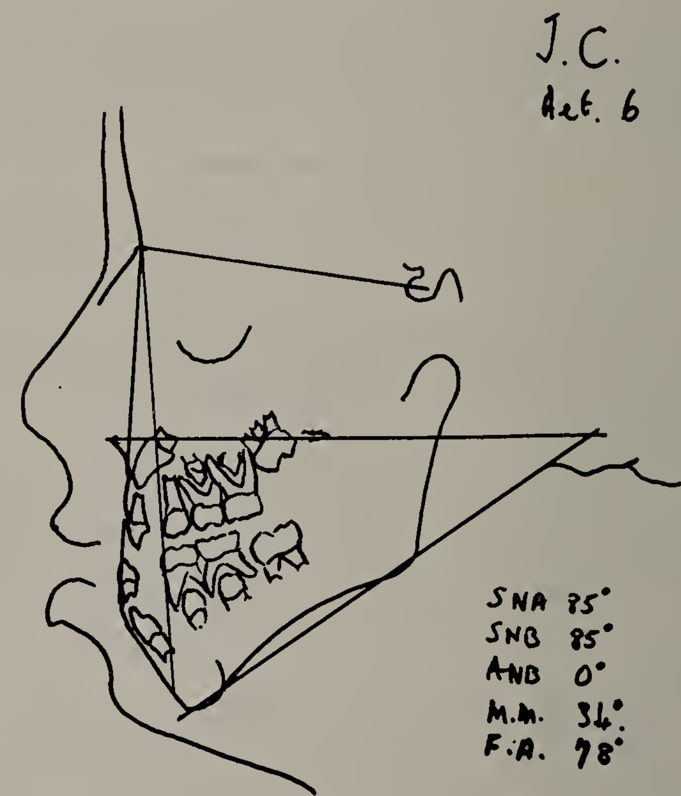

Fig. 3.—*Case J.C.* Macroglossia with exomphalos. Referred for mandibular osteotomy. No mandibular basal prognathism. SNB is large because of the alveolar fullness.

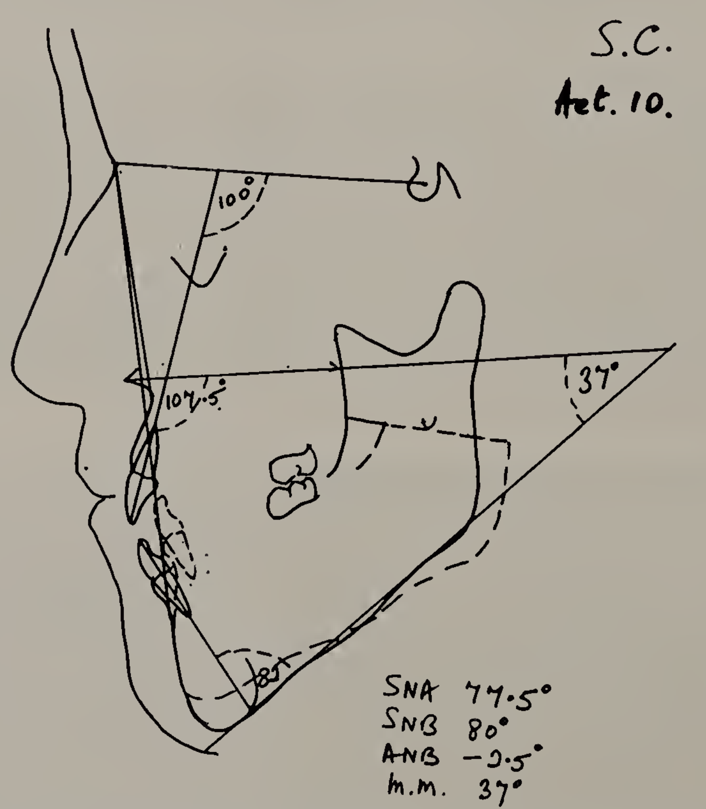

Fig. 4.—*Case S.C.* Anterior open-bite prognathism in a girl of ten years of age. Note the large M.M. angle.

The child whose tracing is illustrated in *Fig.* 3 was also referred for osteotomy. She proved to be an example of exomphalos with macroglossia, which has recently been described by Irving (1967). Both SNA and SNB give large readings, but it can be seen from the outline of the lower alveolus that the tongue has played a large part in the creation of the Class III malocclusion. There is no basal prognathism. In the absence of a definite pogonion, the facial angle (S.Na.Pg.) is difficult to measure, but is less than the mean for this angle as found by Björk and Palling (1954), which was 80°. A mandibular osteotomy, although it might correct the malocclusion, would give a chinless appearance. Local alveolar surgery may be the better procedure, but a further reduction of the tongue may be necessary in addition to the peripheral trimming of the tongue already carried out in infancy.

The malocclusion illustrated in *Fig.* 4 is an example of the sort of prognathism with anterior open bite in which early surgery of any kind would not be attempted. It is felt that no matter where the site of surgery may be, the direction of subsequent condylar growth would lead to the redevelopment of the anterior open bite. The

dotted outline on the tracing shows the cut that would be necessary through the ramus were such a procedure ever contemplated. It has been found that, even when this was attempted in the adult on one occasion, relapse soon occurred in spite of complete stripping of all muscle insertions from the angle of the mandible. At the end of the growing period an ostectomy of the body or angle of the mandible may be carried out.

THE CHOICE OF OPERATIVE PROCEDURE

The blind Gigli-saw osteotomy has already been associated with relapse. Since no muscle stripping is possible and because there can be no control over the upper fragment two causes of relapse are immediately apparent. One lies in the strong tendency of the masseter and the medial pterygoid muscles to revert to their original plane of action and to bring the mandible forward with them. The second is associated with the uncontrolled displacement of the upper fragment which can easily lead to non-union. Even in the best of these circumstances, if union did occur, it would do so with the upper fragment tilted further forward. In the growing child it will be appreciated that the growth direction of the condyle head is immediately changed and it is now so positioned that the potential for relapse is increased. Nevertheless, it was felt that the ramus would be the site of choice in the young subject provided that a method could be devised that would overcome the objections to blind osteotomy. As both the body and the angle of the mandible in the young child contain developing teeth, it was felt that these regions should be avoided if at all possible. Neither was it thought that the ramus of the mandible in the young child would be suitable for the sagittal splitting technique. The procedure chosen has been described elsewhere (Knowles, 1967). It entails planning the direction and height of the cut through the ramus from the cephalometric film so that a template may be made to transfer this information on to the ramus at the time of operation. An external approach is mandatory in order to achieve the objectives of the procedure, which are as follows:—

1. The stripping of the masseter and the medial pterygoid muscles from their insertions.
2. Relating the direction of the cut through the ramus to the plane of movement of the body of the mandible when re-positioned. This is achieved by means of the template. In this way, an exact approximation of the bone-ends is possible.
3. The passing of an interosseous wire between the bone-ends to control the upper fragment and to ensure that the relationship of the condyle head to the glenoid fossa is not altered. The importance of this, especially in the growing child, has already been referred to.

In addition, the new position of occlusion is planned to give sufficient overcorrection of the lower incisor position to allow for their postoperative proclination. This can be as much as 7° (Hovell, 1964).

CASE REPORTS

So far, six young subjects have been under review for a sufficient length of time to enable an interim report to be given of the postoperative sequelae. By chance, they can be placed in two groups of three, the distinguishing feature between them being a difference in the M.M. angle. The first group has an M.M. angle of the mean normal value of around 26°. The second group has a M.M. angle of 29° and some variation in the postoperative results. The tracings which follow give the overall changes that have occurred between the first and last headplates. More local changes will be illustrated later.

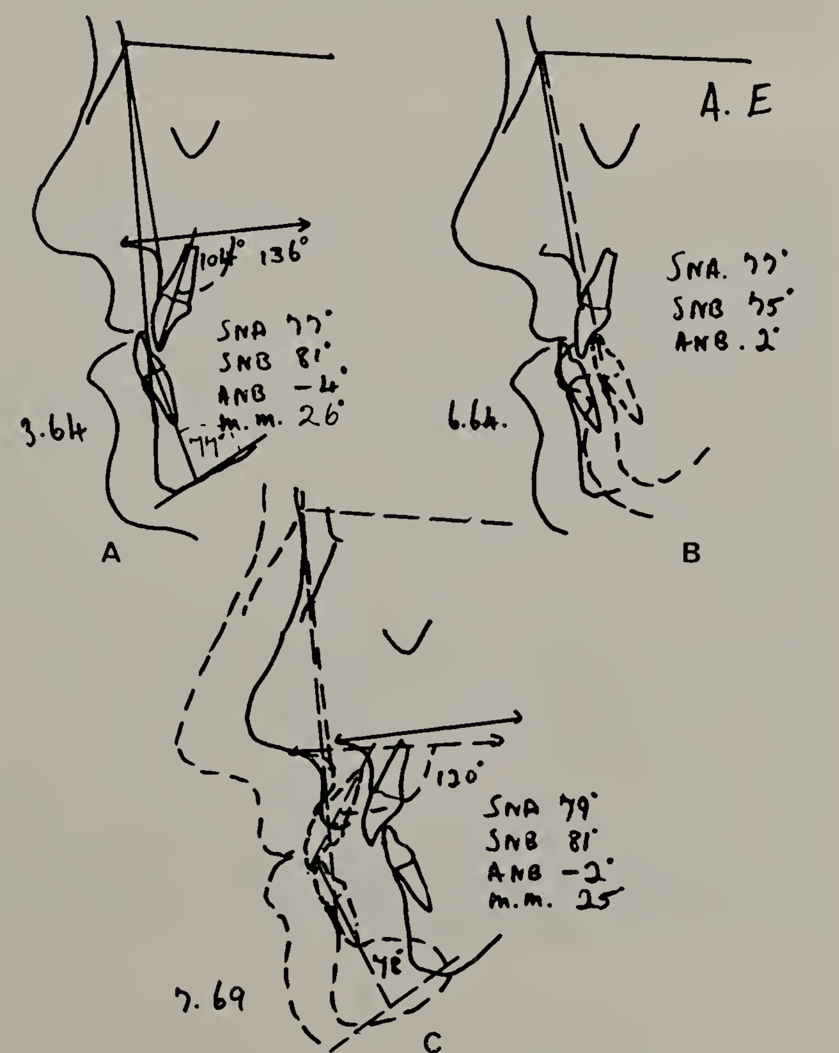

Fig. 5.—*Case A.E.* A, Preoperative condition. 136° is the angle to which the upper incisors would need to be proclined to come over the lowers. B, Postoperative relationship achieved. C, Five years postoperative occlusion compared with immediately postoperative. Note the posterior lowering of the maxillary plane.

Group One—Average M.M. Angle

Case A.E. (*Fig.* 5)

This patient was aged 9 years, 4 months at operation and shows a tendency to some middle third deficiency with an SNA of 77° which is 1° less than the mean for Class III malocclusions investigated by Mills (1966). SNB, however, is a little more than the corresponding mean of 80° found by the same investigator. Both upper and lower incisors show considerable retroclination. In planning the osteotomy, not

too much overcorrection of the lower incisors was allowed in the hope that they would, on making contact with the uppers, procline these. The tracing dated June, 1964, shows the immediate postoperative position when a reduction of 6° in both SNB and ANB was achieved. After 5 years, the following changes may be noted. There is a tendency to develop

The initial correction increased ANB to 9°, which has reduced to 5° after a period of 4 years, and in the same period SNB has also changed, but by 1° less than the reduction of ANB. This may indicate a tendency to a relative increase in mandibular basal prognathism. Both the upper and the lower incisors have proclined and the maxillary plane has tilted

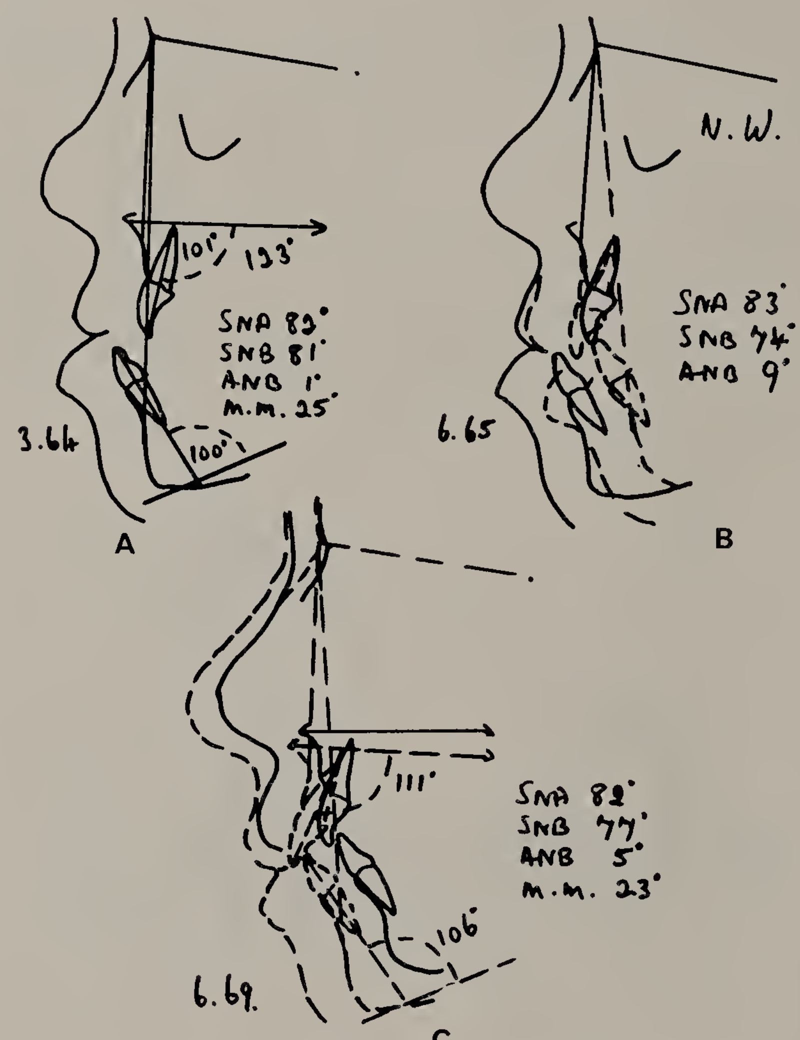

Fig. 6.—*Case N.W.* A, Preoperative condition. B, Postoperative condition. C, Four years postoperative occlusion compared with immediately postoperative.

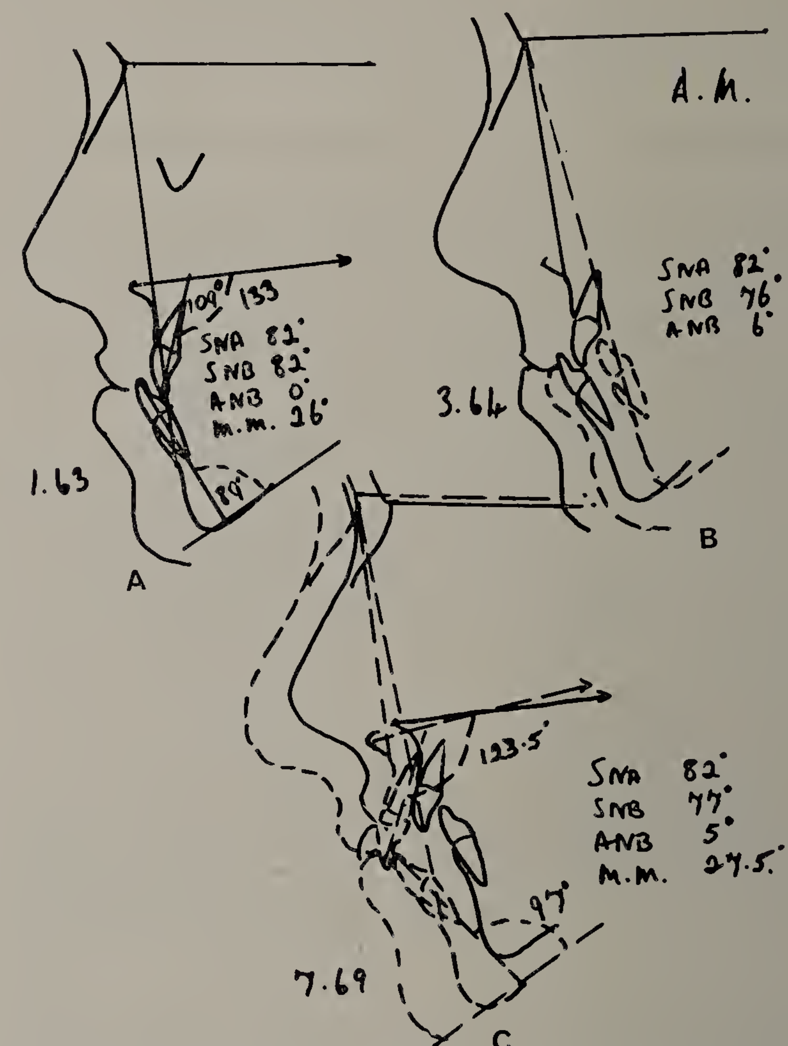

Fig. 7.—*Case A.M.* A, Preoperative condition. B, Postoperative condition. C, Five years postoperative occlusion compared with immediately postoperative. Note the anterior downward tilt of the maxillary plane.

a lower facial prognathism and, although the upper incisor inclination has increased by 16°, this increase has been brought about more by mandibular growth and not by the proclination of the lower incisors which has only increased by 1°. SNA has increased by 2° due to the re-modelling of the upper alveolus. This has compensated for a return of SNB to the preoperative value. The maxillary plane has descended posteriorly. It may be considered that the middle third of the face has benefited from these growth changes associated with the establishment of a more normal jaw relationship.

Case N.W. (*Fig.* 6)
This patient was aged 9 years, 7 months at operation. Although ANB is 1°, there is a large reversed overjet and it will be seen from the tracing that the lower incisors have a considerable proclination and that the upper incisors are retroclined. A rearrangement of these inclinations will give a normal occlusion when carried out on the tracings but it did not seem that this would be a suitable form of treatment on clinical assessment. It was felt that the best effect would be obtained through osteotomy.

posteriorly. In association with this latter change, the M.M. angle has reduced.

Case A.M. (*Figs.* 7, 8)
This child was aged 10 years at operation and has been under review for $6\frac{1}{2}$ years after osteotomy. During that time, ANB has only reduced by 1°. Lower face prognathism has not increased and it can also be seen that the maxillary plane has behaved differently than in the previous two cases by lowering anteriorly. As an increase in the M.M. angle has also occurred, these two changes taken together indicate a slightly different pattern of facial growth in this patient as compared with the previous two cases. Here may be seen a rather more vertical than horizontal growth tendency.

Group Two—Larger M.M. Angle
Case W.L. (*Fig.* 9)
This child was aged 10 years, 6 months at operation and only 3 years have elapsed since the osteotomy. So far the ANB has remained stable and only a small degree of incisor proclination has occurred. However, the maxillary plane has dropped anteriorly and the M.M. angle has increased.

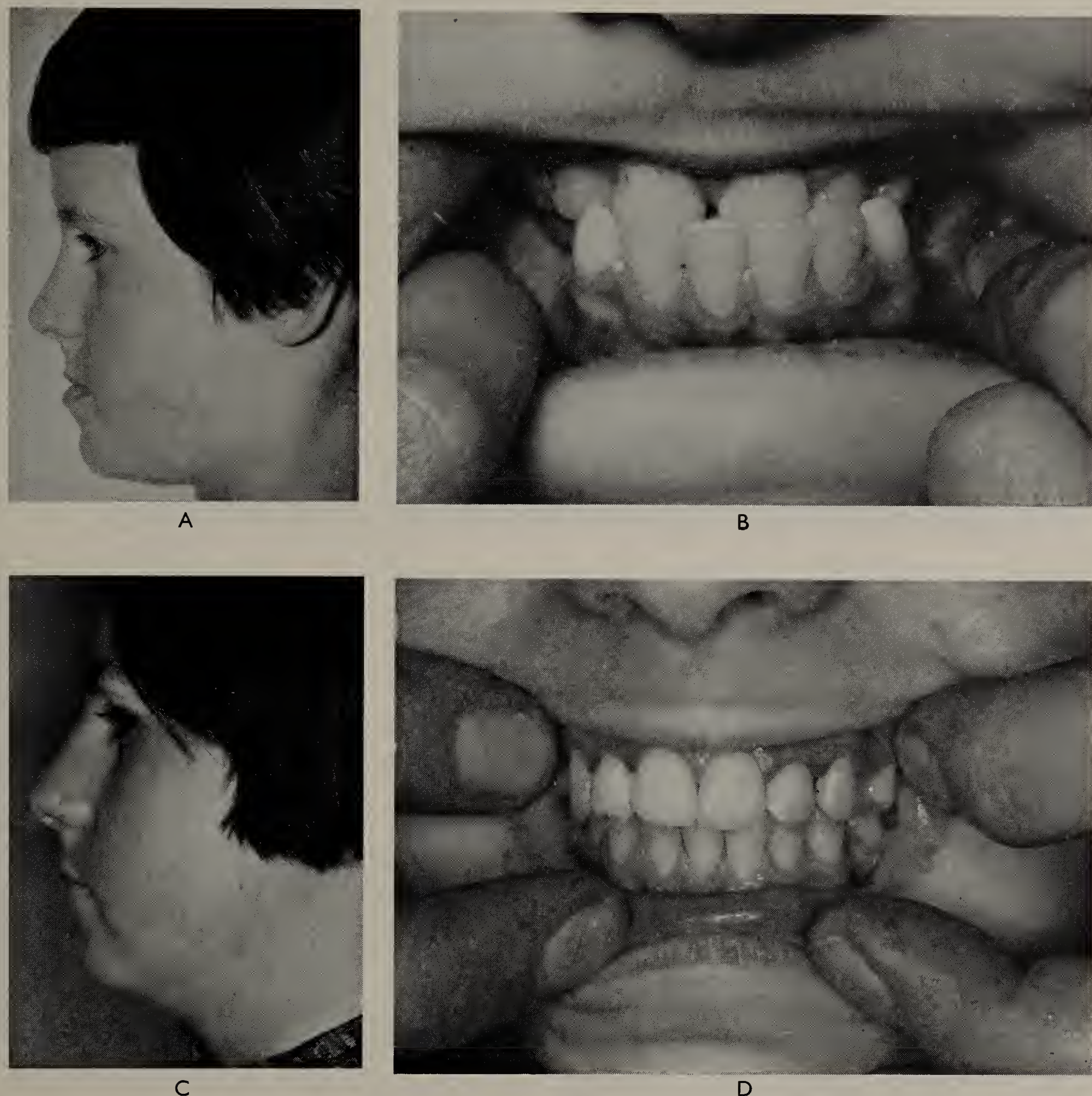

Fig. 8.—A, B, Preoperative condition of *Case A.M.* (*Fig*. 7). C, D, Postoperatively.

Case R.G. (*Figs*. 10, 11)
This child was aged 9 years, 3 months at operation and is the only boy in the series. At the time of his osteotomy he was quite a small child, but during the 5 years of his review he has grown to a height of 6 feet. Although there is evidence of the development of lower facial prognathism and ANB is now fractionally less than the original, reference to the tracings will show that this is due to a reduction in SNA by 2°. Again, the drop at the front of the maxillary plane may be noted.

Case P.McK. (*Fig*. 12)
This patient was aged 9 years, 9 months at operation, and in the first 2 years after osteotomy showed a fairly rapid reduction of ANB. This was associated with a retroclination of the lower incisors—the only occasion in the series when this has happened. Although ANB has remained unaltered in the last 2 years, there has been a proclination of the lower incisors to bring them into Class III occlusion. The vertical element of mandibular growth has reduced the overbite sufficiently for the lower incisors to escape.

Group Three
Three other cases may now be mentioned. They are in the slightly older age-range and their osteotomies were carried out at the beginning of their 'teens.

The period of postoperative observation has not yet extended long enough to form any definite conclusions; but their tracings are included to show the changes that have occurred so far.

Case L.B. (*Fig.* 13)

There is a large negative ANB of −8° and the facial angle is considerably in excess of the mean normal value. SNA comes at the lower end of the range for Class III samples and its value would indicate some deficiency in the middle third of the face. Clinically, there is a small, narrow, crowded maxilla.

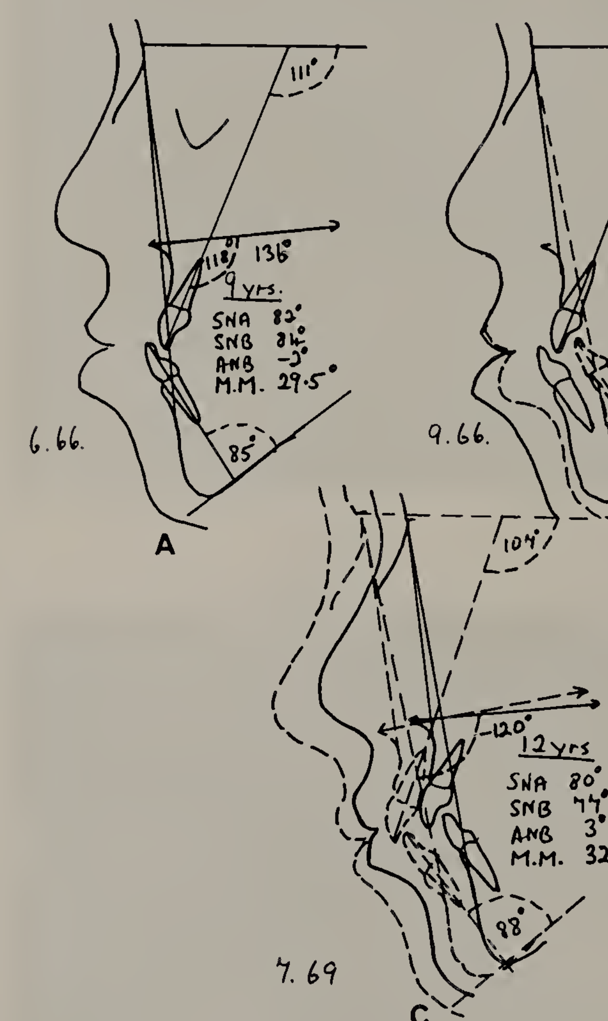

Fig. 9.—*Case W.L.* A, Preoperative condition. B, Postoperative condition. C, Three years postoperative occlusion compared with immediately postoperative. Note the anterior downward tilt of the maxillary plane and an increase in the M.M. angle.

It may be seen that there is a considerable retroclination of the lower incisors.

After osteotomy, an ANB of −5° was achieved, which has remained stable for 3 years. Some proclination of the lower incisors took place and the already large M.M. angle has increased by a further 3°.

Case K.S. (*Fig.* 14)

A very considerable proclination of the upper incisors is present. The only changes that have occurred after 4 years have been an increase in lower incisor proclination of 4° and a small increase in lower face prognathism as evidenced by an increase of 1° in the facial angle. There is also a possible reduction in the upper incisor proclination.

Case B.F. (*Fig.* 15)

In this example, the same excessive proclination of the upper incisors is shown. Because this case and the previous one showed this feature, it was thought that the tongue may have played a part in the positioning of the upper incisors and that it might similarly affect the lower incisors postoperatively. Therefore, in these two subjects, a considerable overcorrection of the lower incisors was allowed. In *Case K.S.* a lower incisor proclination of 4° occurred, but in the one under discussion, there was, in fact, a retroclination of 3°. However, this case shows more tendency to relapse and has developed a fair degree of lower face prognathism since the facial angle (S.Na.Pg.) has increased by 5° in the postoperative period of 3½ years. A reduction in the upper incisor proclination of 4° is

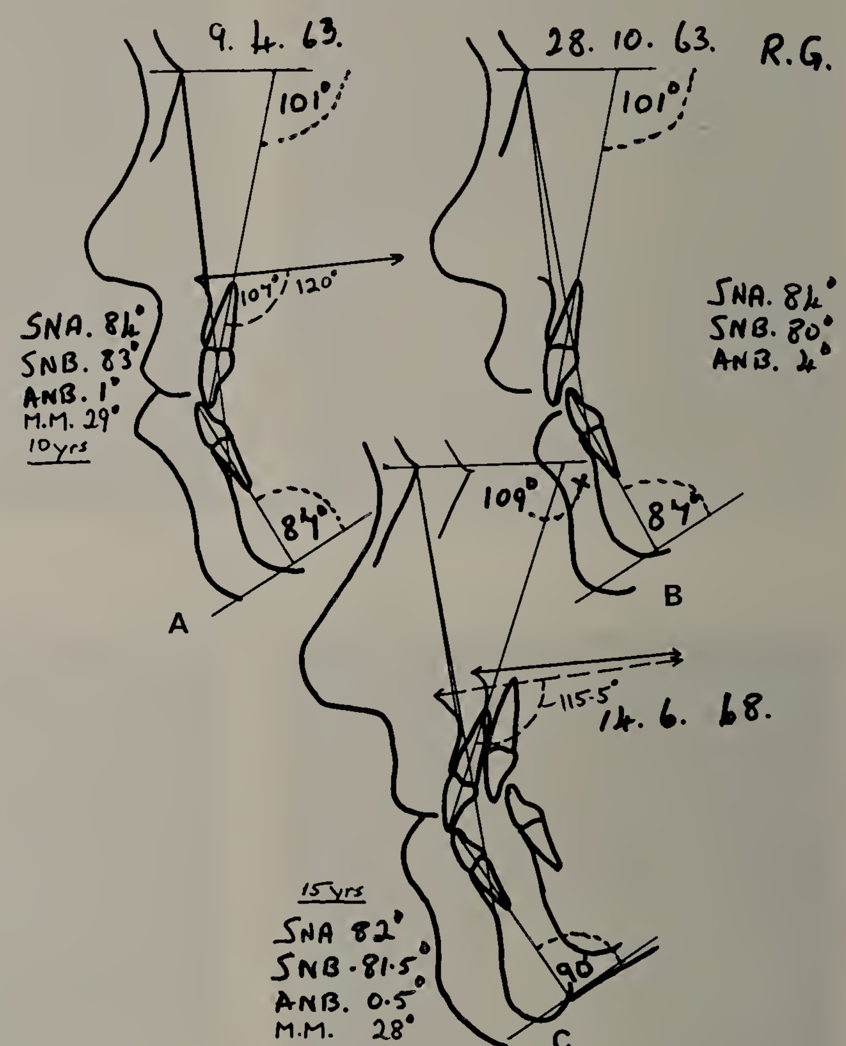

Fig. 10.—*Case R.G.* A, Preoperative condition. B, Postoperative condition. C, Five years postoperatively. The value of SNA is 2° less than in A. Although SNB is also less, the net result is a reduction in ANB.

shown and this may be due to the change in the plane of the orbicularis oris musculature following the re-positioning of the mandible.

DISCUSSION OF THE POSTOPERATIVE CHANGES

Since fewer changes have been found in the older subjects they may be discussed first. These are concerned chiefly with lower incisors, the facial-angle value, and the soft-tissue profile. It is well-known that lower incisors undergo a change of inclination after the re-positioning of the mandible—usually a proclination, but in one of the older cases, a variation from this general rule will be discussed.

The facial angle has been compared because it was thought to be a useful indication of the degree of relapse that might have occurred. Since one of the main objects of treatment is to improve facial appearance, the changes in profile shape have an important place in the assessment of the postoperative results.

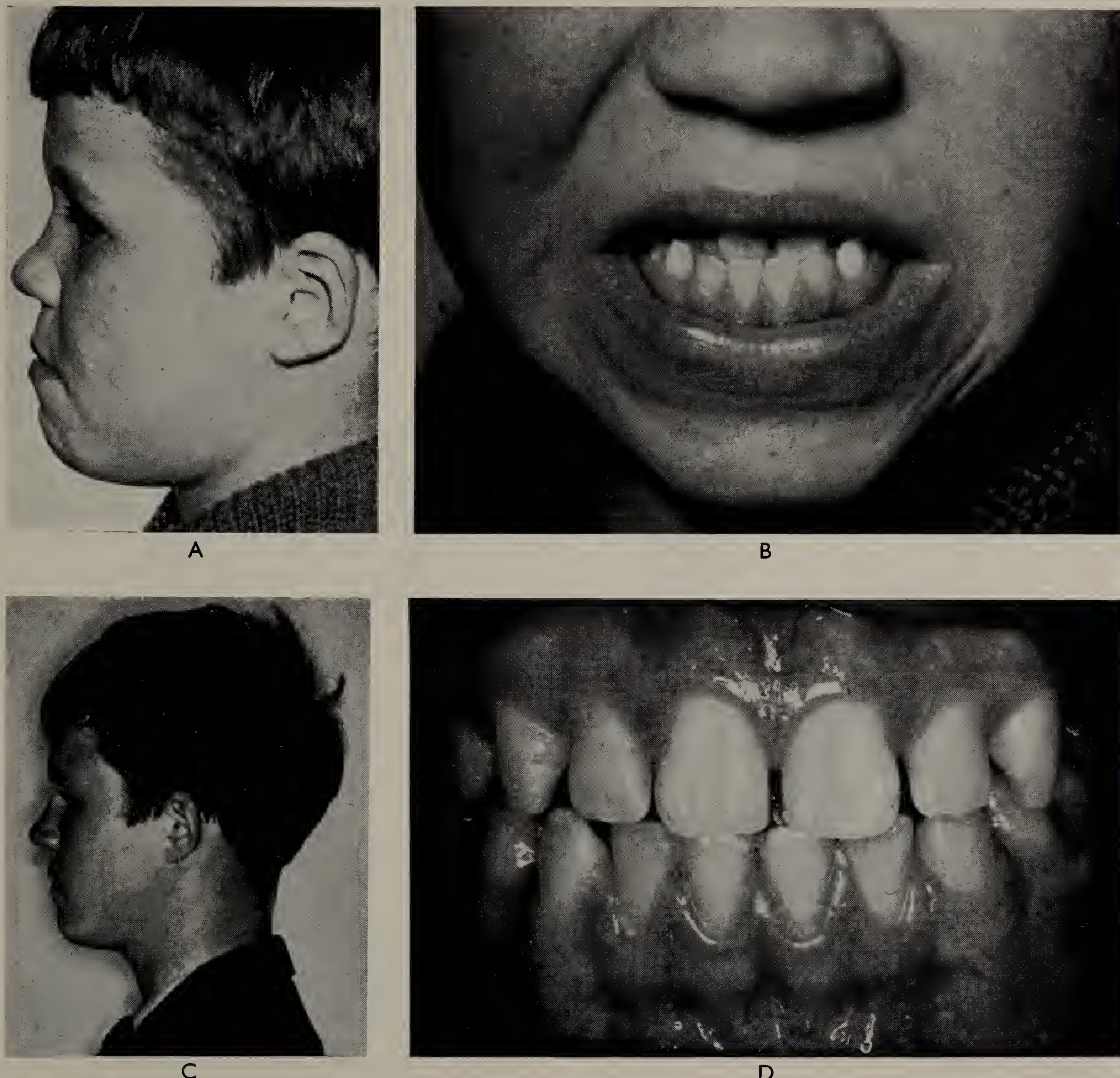

Fig. 11.—A, B, Preoperative condition of *Case R.G.* (*Fig.* 10). C, D, Postoperatively.

In the younger subjects changes were found in other regions and these include upper incisor inclination and the tilt of the maxillary plane as indicated by the line ANS, PNS. The implications of these changes are discussed under the appropriate headings. As far as the measurements which are common to both the older and the younger subjects are concerned the same criteria may be applied.

In the Older Cases

Lower Incisors

In two of the cases, *L.B.* and *K.S.*, some proclination of the lower incisors occurred. This is the usual finding after osteotomy and may be attributed to the changed relationship between the tongue, lower lip, and lower incisors. In *Case B.F.*, in whom a greater tendency to relapse was present, there has been a retroclination of the lower incisors as well as of the uppers. The change in the upper incisors has been attributed to a re-orientation of the plane of action of the orbicularis oris musculature and, within this environment, the lower incisors may be expected to retrocline with the further forward growth of the mandible which occurred. The only other changes that will be discussed in the older cases are those in the facial angles and the profiles.

Facial Angle (*Fig.* 16)

Only *Case B.F.* shows any postoperative increase in this angle, which is associated with her tendency to relapse and not apparently associated with any obvious change in the shape

of the chin outline and the development of the mental prominence.

Profiles (*Fig.* 17)

The postoperative increase in the facial angle in *Case B.F.* is reflected in the profile, which shows a little prognathism, although the outline is still better than the original. In *Case K.S.* the profile is changed as far up as the tip of the nose essentially dental nature of the relapse caused by the proclination of the lower incisors after their escape from their upper opponents. *Cases R.G.* and *A.E.*, in particular, show the development of the mental prominence.

Upper Incisors (*Fig.* 19)

Superimposition has been made on ANS and PNS. The ANS superimposition shows changes

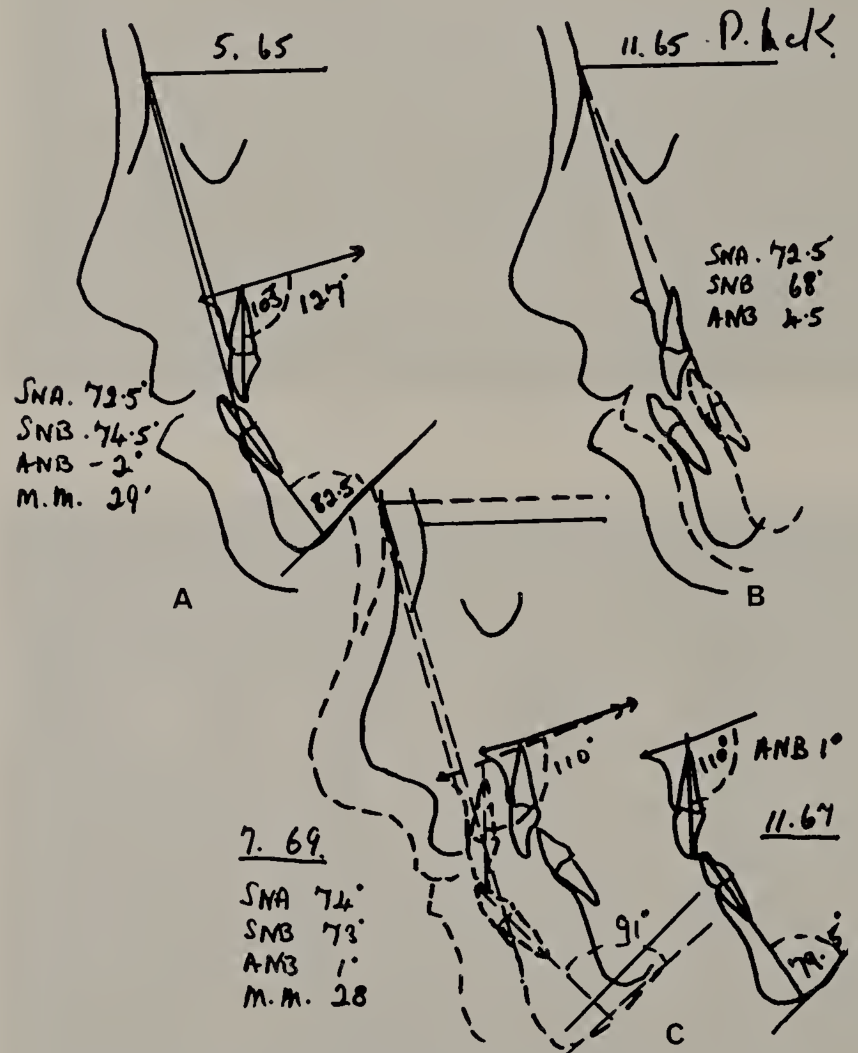

Fig. 12.—*Case P.McK.* A, Preoperative condition. C, Four years postoperative occlusion compared with that two years postoperatively. Note the labial tilt of the lower incisors but no change in ANB.

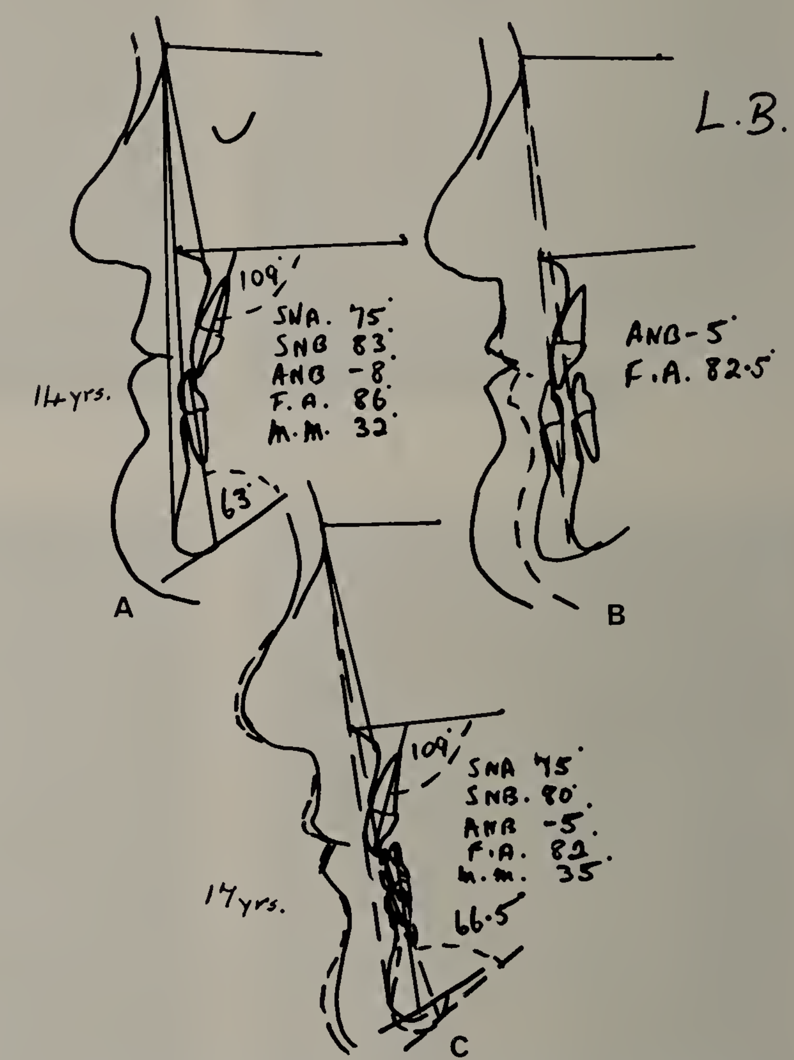

Fig. 13.—*Case L.B.* A, Preoperative condition. B, Postoperative condition. C, Three years postoperative occlusion compared with immediately postoperative, showing very little postoperative change. The M.M. angle has increased by 3°.

and this alteration may be explained by the change that has occurred in the plane of action of the muscles of facial expression. Similar changes in adult subjects have already been reported (Knowles, 1965). The change in the outline of the nose in *Case L.B.* is due to growth. It may be noted that the angle between the lip and the columella has become more rounded.

In the Younger Cases

Lower Incisors (*Fig.* 18)

Superimposition is on the mandibular plane with the lower incisor apex of the postoperative outline registered on the long axis of the preoperative position. Apart from the changes in angulation shown in the diagrams, local changes in the chin contour and alveolar outline may be seen. The tracing of *Case P.McK.* shows the in alveolar shape affecting the position of the ' A ' point, but SNA will not necessarily be affected, since the anterior nasal spine may well have grown forward in the interval. The M.M. angle is shown on the diagrams and it may be noted that the greatest increase in upper incisor proclination has occurred in those with the smaller M.M. angles. This could be interpreted as indicating a moderate preponderance of horizontal growth component over the vertical element. The changes in lower incisor inclination are given on the ANS diagram, but no correlation can be found between these figures and those for the upper teeth.

Superimposition on PNS serves to show a variety of changes in maxillary base length and from the appearance of the different outlines it would seem that those with the larger M.M.

angles have increased more in maxillary length whereas those with the smaller M.M. angles have a greater tilt of the upper incisors.

Maxillary Plane Angulation

The tracings in *Figs.* 5–12 indicate that the maxillary plane has tilted down anteriorly in all those cases with the larger M.M. angles but has tilted down posteriorly in two of those with the small M.M. angles and anteriorly in one of them. In this latter case, however, it will be seen that the M.M. angle has also increased. In connexion with the changes in the inclination of the upper incisors, comment has already been made on a possible connexion between the M.M. angle and the balance between horizontal and vertical

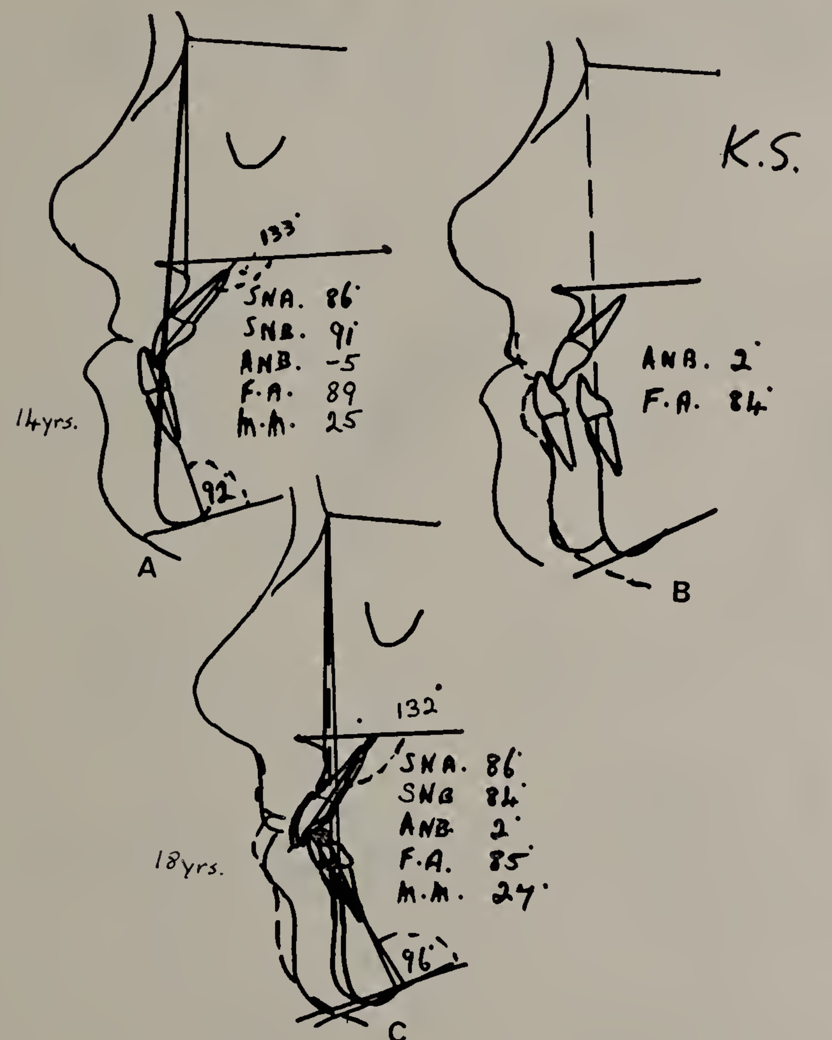

Fig. 14.—*Case K.S.* A, Preoperative condition. B, Postoperative condition. C, Four years postoperative occlusion compared with immediately postoperative. A slight increase in lower facial prognathism may be seen.

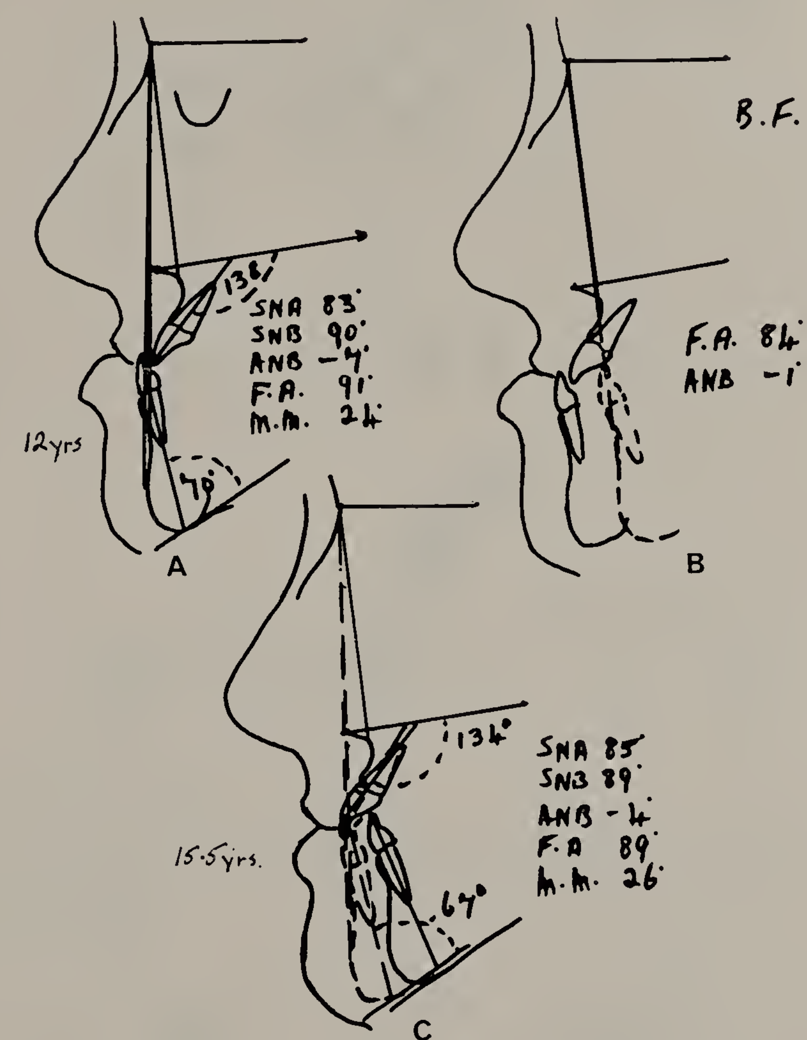

Fig. 15.—*Case B.F.* A, Preoperative condition. B, Postoperative condition. C, Three years postoperative occlusion compared with immediately postoperative. Some relapse has occurred, but the incisor occlusion is still correct and the profile reasonable.

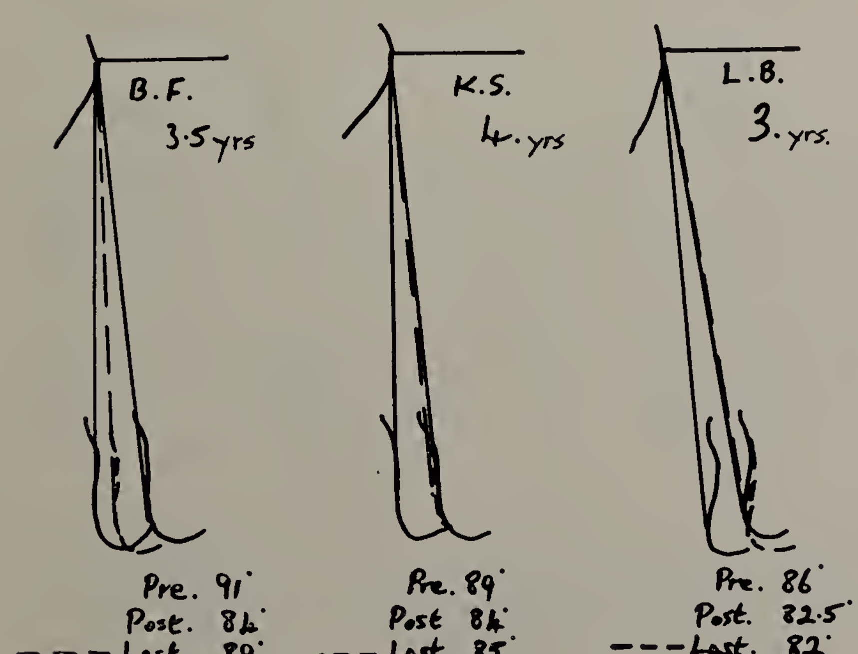

Fig. 16.—The facial angle—older subjects, giving the time interval between the preoperative outline and the last (dotted).

Fig. 17.—The older profiles. *Case B.F.* shows some profile relapse reflected in the facial angle.

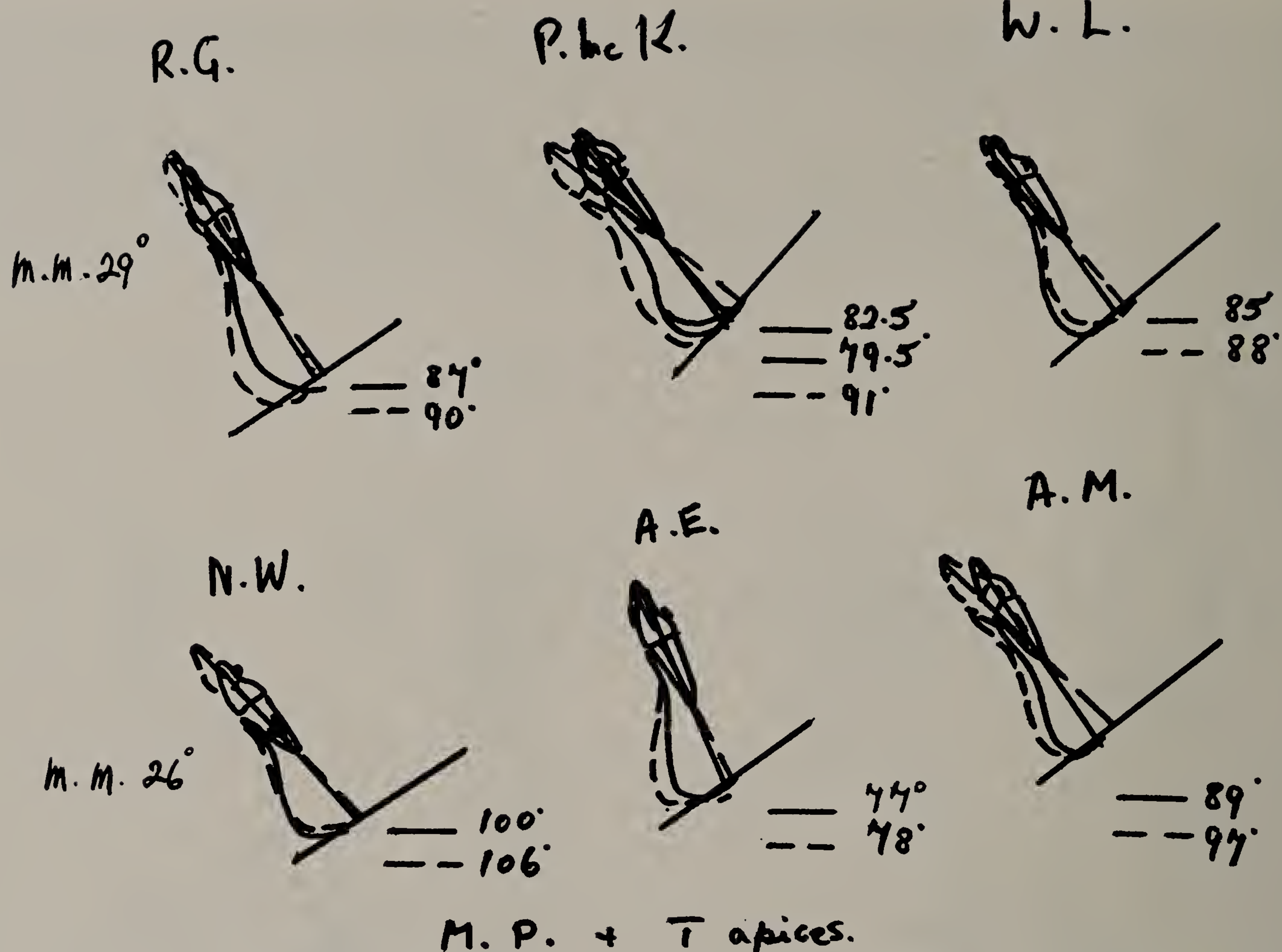

Fig. 18.—The younger subjects. Lower incisor and mental prominence changes. Method of superimposition described in the text.

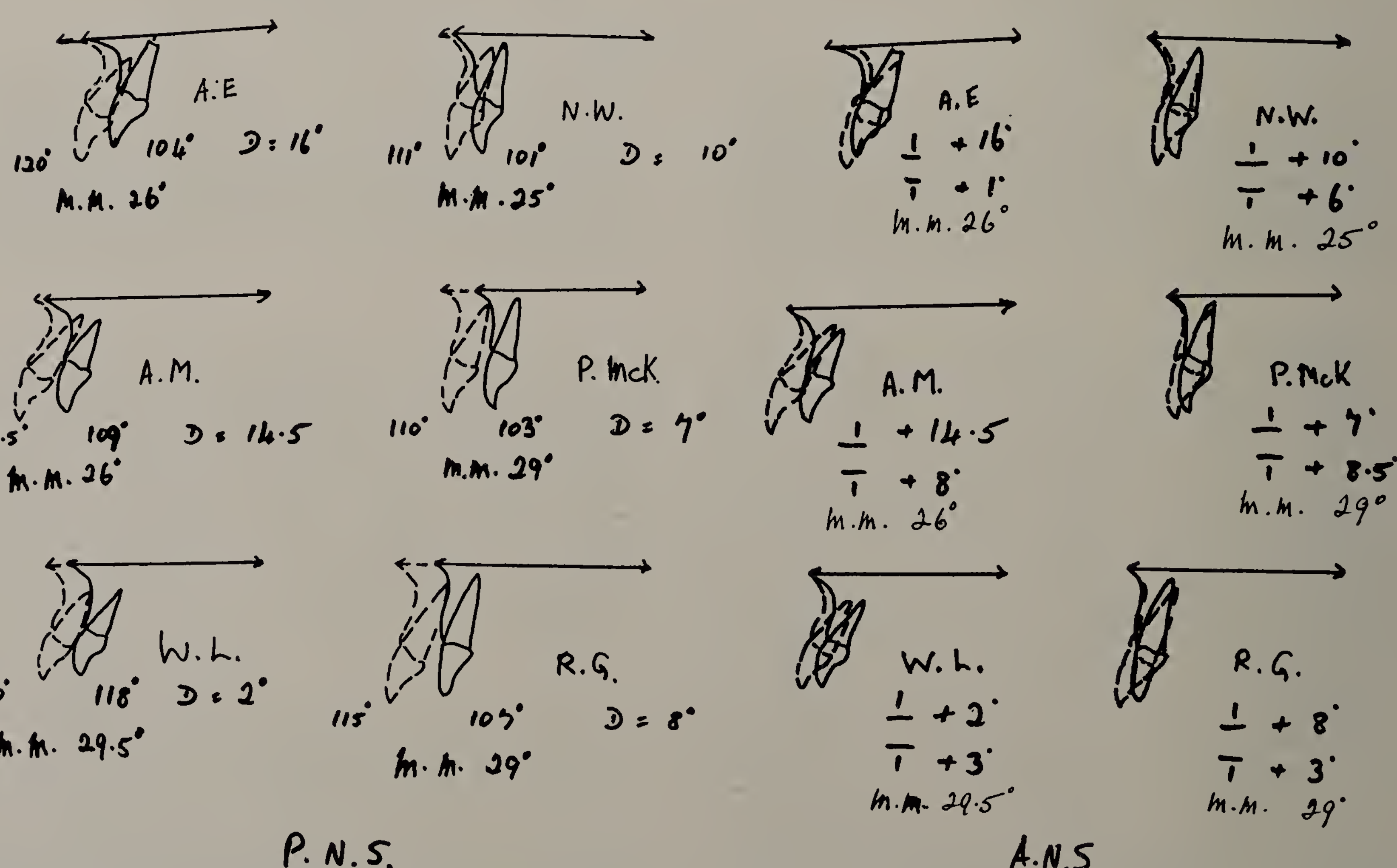

Fig. 19.—The younger subjects. Changes in the upper incisors and alveolus. Superimpositions on ANS and PNS.

growth, and a similar relationship can be found in the changes that have occurred in the tilt of the maxillary plane. In the three cases with the larger M.M. angles, the maxillary plane tilted down more at the front as an indication of a more vertical type of facial growth; and this also occurred in one of those with the smaller M.M. angle (*Case A.M.*) in whom the M.M. angle increased during the period of observation. Although the number of cases is only small, these changes may at least indicate a tendency for middle-third growth to follow the direction taken by the mandible and, as long as this continues, then incisor overbite should not become too much reduced.

Facial Angle (*Fig.* 20)

As indicated earlier, the angle S.Na.Pg. has been used. Pogonion was chosen deliberately so that changes in the facial angle may correlate with the effect of the osteotomy upon the profile, upon which the development of a mental prominence will have an effect. The superimposition of tracings is on SNA with Na. registered. It may be seen that the changes that have occurred have varied considerably. *Cases A.E.*, *R.G.*, and *P.McK.* show the closest return to the preoperative figures and these are the ones in whom the mental prominence has developed to the greatest extent (*Fig.* 18). All except *Cases N.W.* and *W.L.* show a good increase in vertical height, but as these two are a little younger, their facial height may yet develop.

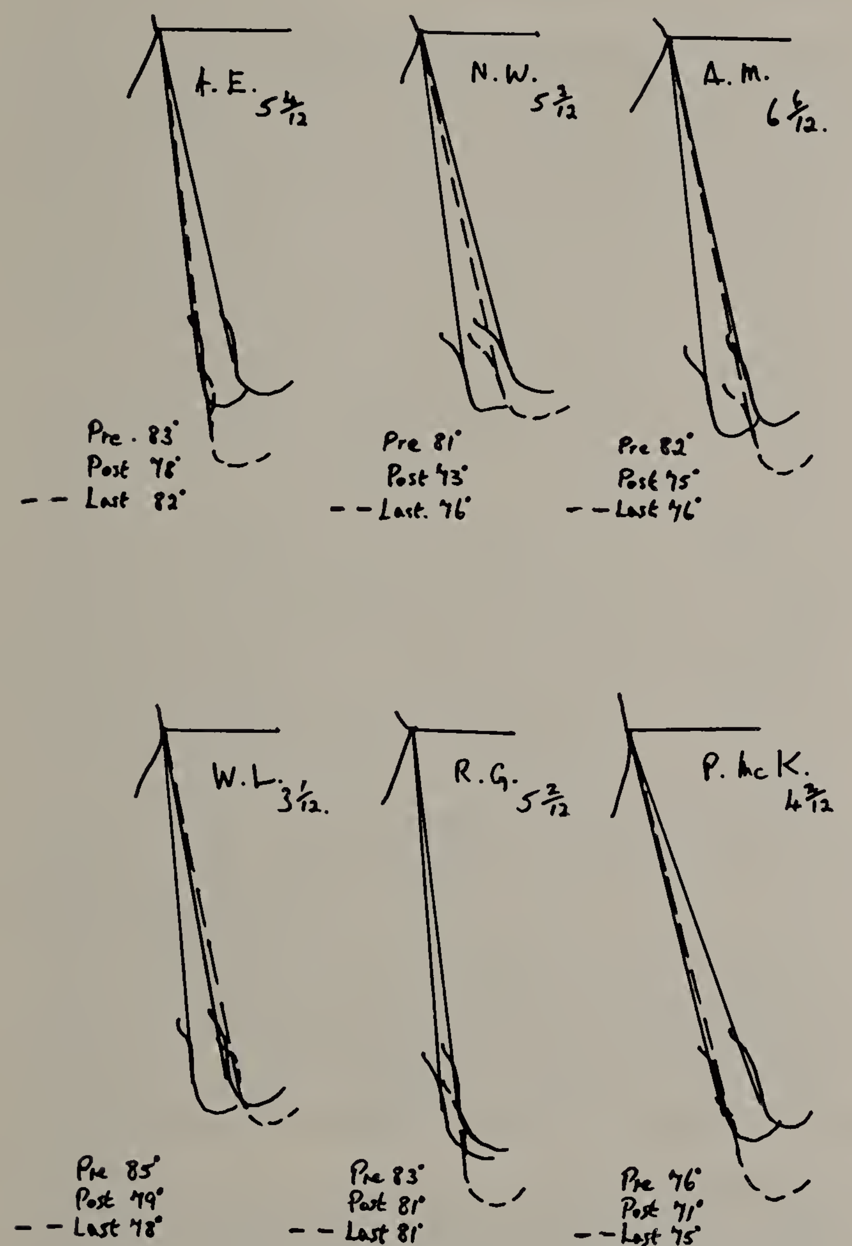

Fig. 20.—The facial angle, younger subjects. Time interval between the preoperative outline and the last is given in years.

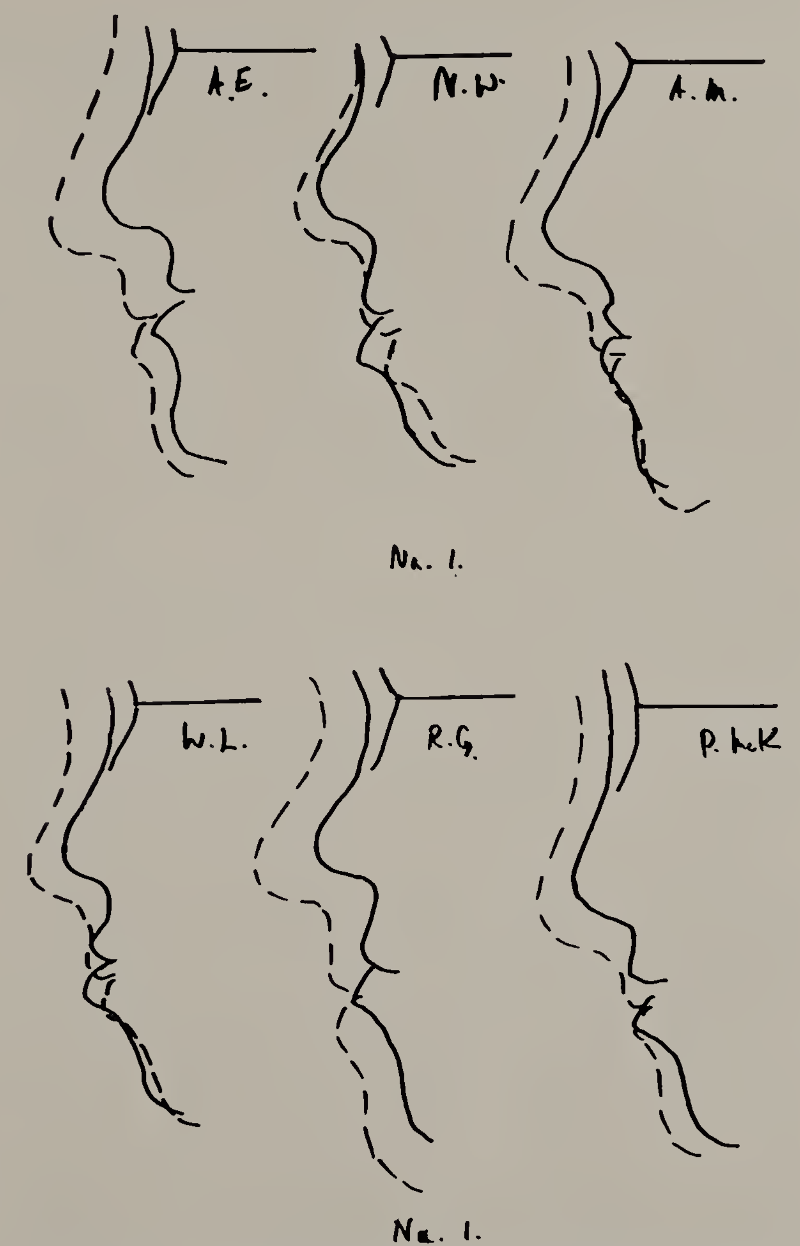

Fig. 21.—Profile changes, younger subjects. The middle third of the face has become relatively more prominent than the lower third. All show considerable improvement in the outline of the soft-tissue profile.

Profiles (*Fig.* 21)

The tracings were superimposed on the nasion and the posterior cranial outline with the line S.Na. parallel. In all cases, except possibly *Case R.G.*, greater middle-third growth is shown as compared with lower third which, in effect, has suffered a ' set-back ' due to operative interference. The total amount of condylar growth occurring has probably been no different in amount than if the osteotomy had not been performed. The general improvement in the soft-tissue outline may be noted.

SUMMARY

Cases of early osteotomy have been shown in whom surgery was performed because it was not believed that early correction would inevitably lead to relapse if the following conditions were fulfilled:—

1. Only Class III malocclusions with a deep overbite were chosen.

Table I.—Summary of the Major Changes in the Six Cases Reviewed

	SNA	Diff.	SNB	Diff.	ANB	Diff.	F.A.	Diff.	$\underline{1}$	Diff.	$\overline{1}$	Diff.
Case A.E.												
Preoperative	77		81		−4		83		104		77	
Postoperative	79	+2	81	0	−2	2	82	−1	120	16	78	1
Case N.W.												
Preoperative	82		81		1		81		101		100	
Postoperative	82	0	77	−4	5	4	76	−5	111	10	106	6
Case A.M.												
Preoperative	82		82		0		82		109		89	
Postoperative	82	0	77	−5	5	5	76	−6	123·5	14·5	97	8
Case W.L.												
Preoperative	82		84		−2		83		118		85	
Postoperative	80	−2	77	−7	3	5	81	−2	120	2	88	3
Case R.G.												
Preoperative	84		83		1		83		107		87	
Postoperative	82	−2	81·5	−1·5	0·5	−0·5	81	−2	115·5	8·5	90	3
Case P.McK.												
Preoperative	72·5		74·5		−2		76		103		82·5	
Postoperative	74	1·5	73	−1·5	1	3	75	−1	110	7	91	8·5
Mean	0		−3·16		−3		−3		+9·6		+6	

2. The osteotomy was carried out in such a way that the condyle head did not suffer a change in position so that, in turn, the future growth direction would not be altered.

The postoperative growth changes do not show any gross relapses although in one or two instances there has been a development of some mental prominence, but this would have occurred in any case. *Table I* sums up the changes and, although the number of cases is only small, it was thought that the mean figures may be of interest. They show a reduction in those readings indicating mandibular prognathism, i.e., SNB, ANB, and FA, with an increase in upper and lower incisor inclinations—greater in the case of the upper incisors.

CONCLUSIONS

It is not the intention of this report to advocate the performance of routine early osteotomies. It may, however, be noted that no sudden relapses have occurred and, so far, none of the cases has needed a second operation. The period of observation is not yet over and future growth may lead to a change of opinion. The cases have been presented because there did not appear to have been a previous analysis of the postoperative changes in early osteotomies, or very much recorded data of any such surgical procedures which may be used as a basis for future discussions and decisions.

Acknowledgements

The author greatly appreciates the encouragement given to him by his plastic surgery colleagues and the assistance of the medical photographer at Whiston Hospital, Mr. M. Bayliss.

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DISCUSSION

Mr. R. J. Pettman pointed out that Mr. Knowles had shown a case where mention had been made of a large tongue, and had said that it was not a case for operation of the sort described. He suggested that it might have been a case for dental alveolar surgery. Mr. Pettman asked if Mr. Knowles would comment further on this point.

Mr. Knowles replied that in such a case an osteotomy, in which the whole body of the mandible is moved back, would not be suitable because the prognathism lay not with the body of the mandible but with the alveolus, which had been bulged out by the large tongue. In this case local alveolar surgery to reposition the lower incisor region would be the better solution, but some further reduction of tongue size may be needed.

Mr. P. I. Townend asked if changing the function of the mandible affected the growth of the mandible. In effect, was growth affected by function, he asked.

Mr. Knowles replied that his thought on this—which he did not claim to prove—was that, if one established normal incisor occlusion during the growing period, then the support given to the upper incisors would lead to a development of the upper alveolus which in the course of further growth would become the basal bone. Thus, as long as the occlusion remained normal, one stood the chance of obtaining the optimum growth of the maxilla.

Mr. B. S. Cryer drew attention to Mr. Knowles' suggestion that one of the advantages of the operation was that there might be an improvement in speech. Had he found this in the cases in which he had been involved?

Mr. Knowles replied that this was so. None of the cases had had any clear postoperative assessment because, at the hospital where the operation was carried out, they had not had the services of the speech therapist. From a subjective point of view, however, he felt there had been a change in speech in the patients.

Class III patients seemed to have the sort of speech where the tongue ' got in the way '. This seemed to go after the osteotomy, when one established the normal, anatomical basis for speech.

Mr. M. S. E. Gould asked what had happened to the molar occlusions, as well as the incisor occlusions.

Mr. Knowles replied that molar occlusion remained as it had been at the time of the original correction.

In one of the cases—the girl who had received treatment for 6½ years—when they had first corrected her mandible, the lower molar had not occluded with the upper; it had moved out of occlusion. Postoperatively she had been fitted with a simple anterior bite plate. The lower molar had drifted forward into occlusion in three months; otherwise it had not changed appreciably.

Mr. J. Nicol asked if Mr. Knowles had examined the tongue position, in particular, the resting posture of the tongue.

Comment had been made on the low tongue position in certain Class III cases during rest. Had Mr. Knowles noted any change in tongue posture after operation? It would seem that there might be change, if the incisors became a little more proclined, he suggested.

Mr. Knowles replied that, as far as he could gather from the tracings and X-rays, he had found no particular change in tongue position, before or after operation. The tongue was contained in the box of the occlusion; there was no particular change in the tongue shape, or in the size of the pharyngeal air space.

Mr. C. P. Adams thanked Mr. Knowles for an interesting paper which had contained a large number of individual and rather unusual cases for treatment by surgical means.

He had three questions: first, had Mr Knowles said that, if he was able to establish normal occlusion in the children at an early age, this would lead to improvement in the development of the maxilla?

Secondly, it was now generally agreed in these cases that mandibular growth and posture was usually very closely associated with muscular development and muscular function. If that was so, was it not natural to expect that there would be a strong tendency to relapse and, in the young and growing child, and this tendency to relapse would be greater than if the operation were carried out when the patient had reached maturity.

Thirdly, he had met a surgeon in Lyons, France, who carried out a great deal of treatment of this kind. He had maintained there was no point in doing the mandibular resection in severe Class III malocclusion unless partial glossectomy was carried out at the same time. This surgeon did this routinely; the tongue operation first at quite an early age and, if this were not sufficient, he would follow it by mandibular resection.

Mr. Knowles, in reply to Mr. Adams' first question, said that as one would be likely to get some increased proclination of the upper incisors, one might get some change in the profile, depicted by the part shown in the measurement SNA. One might also influence the pattern of surface opposition on the front of the alveolar process in some cases where there was more hollowing out of the alveolus so that SNA had been reduced. In those cases one did not necessarily achieve the theoretical objective. In other cases there had seemed to be some extra increase in the fullness of the part of the alveolus process below the spine.

With regard to the muscles, the masseter and internal pterygoid muscles were very carefully detached. When the wound was closed, they were allowed to hang down naturally in their usual direction of action. The plane of action was not changed and the muscles were re-attached in the same plane of action. The muscle factor, therefore, would not be operative in causing relapse.

Regarding the tongue, he agreed that the incisors proclined, both upper and lower. They had not carried out any partial glossectomy. It was generally felt, in mandibular surgery, that it was the ostectomy which led to the tongue size being changed in relation to the mandible, postoperatively.

It was felt that, after an osteotomy in the ramus, it was not necessary to do a glossectomy.

Mr. C. D. Parker noted that mention had been made of the tongue, but he would draw attention to the lips. In the cases shown by Mr. Knowles he had observed that, postoperatively, all cases had formed a lip seal very easily. He asked Mr. Knowles if he felt that this arrangement of the lips was the best possible one to withstand the moulding effect of the

tongue postoperatively, thus making any interference or operation on the tongue unnecessary in some cases.

Mr. Knowles replied that this was part of the pattern of establishing the normal anatomical relationship—all helping to maintain the results achieved. By establishing the teeth the right way round and the lips in a more correct posture, this must help to maintain the result achieved. The plane of action of the circumoral muscles was changed, and thus helped to maintain normal soft-tissue relationships between lips, teeth, and tongue.

In all cases in which they had operated, because they did not know the final outcome, parents had been told told that there might be a possibility of having to repeat the surgery, and all of them had accepted that possibility when they had been offered early osteotomy for their children.

Mr. L. A. Usiskin asked how much preoperative observation had been carried out.

Orthodontists would tend to observe the occlusion, watching for any increase of the reverse overjet, he said. If one were to find a progressive increase in the reverse overjet over a period of time, this might be an important indication for the early postoperative observation.

Mr. Knowles replied that as the person got older and bigger everything increased in proportion, so that a young child developing a small reverse overjet, might, if everything increased in proportion, have a bigger reverse overjet when that child was bigger in dimension. It might give the impression of being a progressive increase but, in fact, it was a proportional increase.

They had not carried out a prolonged period of preoperative assessment. They had deliberately chosen those with a good overbite. Those they had only observed were those with an anterior open bite—those were the ones who had the most unfavourable growth direction. Anterior open bites seemed to relapse more easily, and more easily still in the young, after surgery. They had not had a period of review before they did the osteotomy in the cases they had chosen.

A METHOD FOR RETROCLINING LOWER INCISORS IN CLASS III MALOCCLUSIONS

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THIS paper describes a simple fixed appliance which it is felt may be of value in the treatment of Class III incisor malocclusion. Except for cases where the skeletal pattern defect is mild, it is advantageous to retrocline the lower incisors whilst at the same time proclining the uppers (Mills, 1966). In the most severe cases treatable by orthodontic means the upper incisors may already be in a proclined position. In such cases a result may still be obtained by retroclination and retraction of the lower incisors alone.

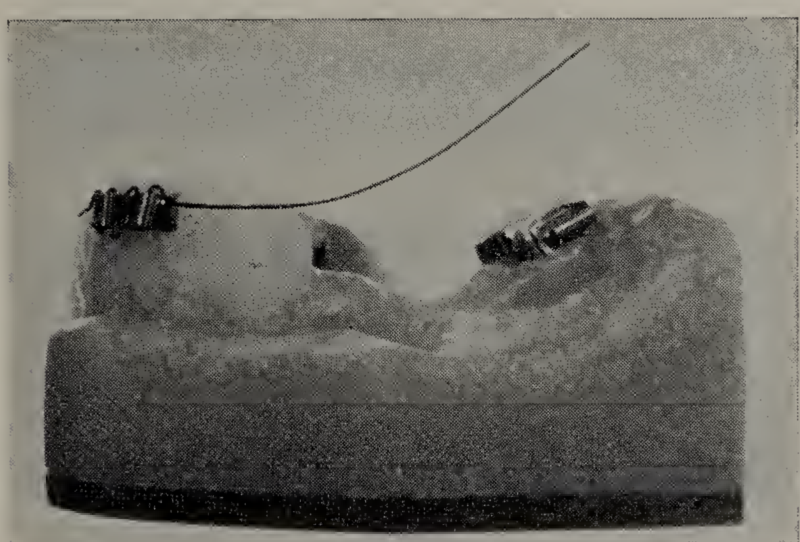


Fig. 1.—The free sliding arch (0·5 mm.) with the loops inserted in the incisor boxes and the free ends in passive position.

Fig. 2.—The free sliding arch with the ends inserted into the buccal tubes on the first molar bands. A torquing action is now produced on the incisor segment.

Fig. 3.—The appliance modified for intra-maxillary traction.

The appliance is a modification of the loop and tube free-sliding arch which has been well described by Clifford (1965) and Mills (1970). Clifford used the free sliding arch to retrocline the upper incisors and in his paper described the ' lever-torque ' principle with which this movement is carried out.

The principle is exactly the same for the lower arch. A band with an attached vertical box is fitted to each lower central incisor and one with a 0·6-mm. internal diameter tube to each lower first molar (*Fig.* 1). A self-supporting labial arch (0·4 mm. to 0·5 mm. in diameter, depending on length) is used to link the incisor to the molar bands. The labial arch is adjusted so that when the ' U ' loops are inserted in the incisor boxes the free ends lie approximately 1 cm. above the molar tubes. If these free ends are now inserted in the molar tubes (*Fig.* 2) a torquing action is set up which will tilt the lower incisors lingually. The interesting feature of the free sliding arch is that this retroclination is achieved without any force being applied to the buccal segments in a mesial direction.

The appliance can also be used to close any residual spacing. This is done by incorporating a loop on each side at the level of the canine. An elastic band is then extended between the loop

Presented at the meeting held on 10 November, 1969.

and the free end (*Fig*. 3). The advantage of this mechanism is that the reciprocal action produced in bringing the buccal segment forward is expended against the incisal segment. If the incisal segment should move bodily in a lingual direction this can only be to the benefit of the overall treatment plan.

There are two practical points which should be mentioned. (1) The vertical box, as supplied by the dental trade is designed for the upper incisors. This may be too wide for some lower incisors, in which case it may be necessary to make a narrower box by hand. (2) The archwire is modified from the design described by Clifford (1965), so that instead of passing from the loop down into the buccal sulcus it passes across the lateral incisor and canine. Lateral incisors and canines are thus retracted with the central incisors.

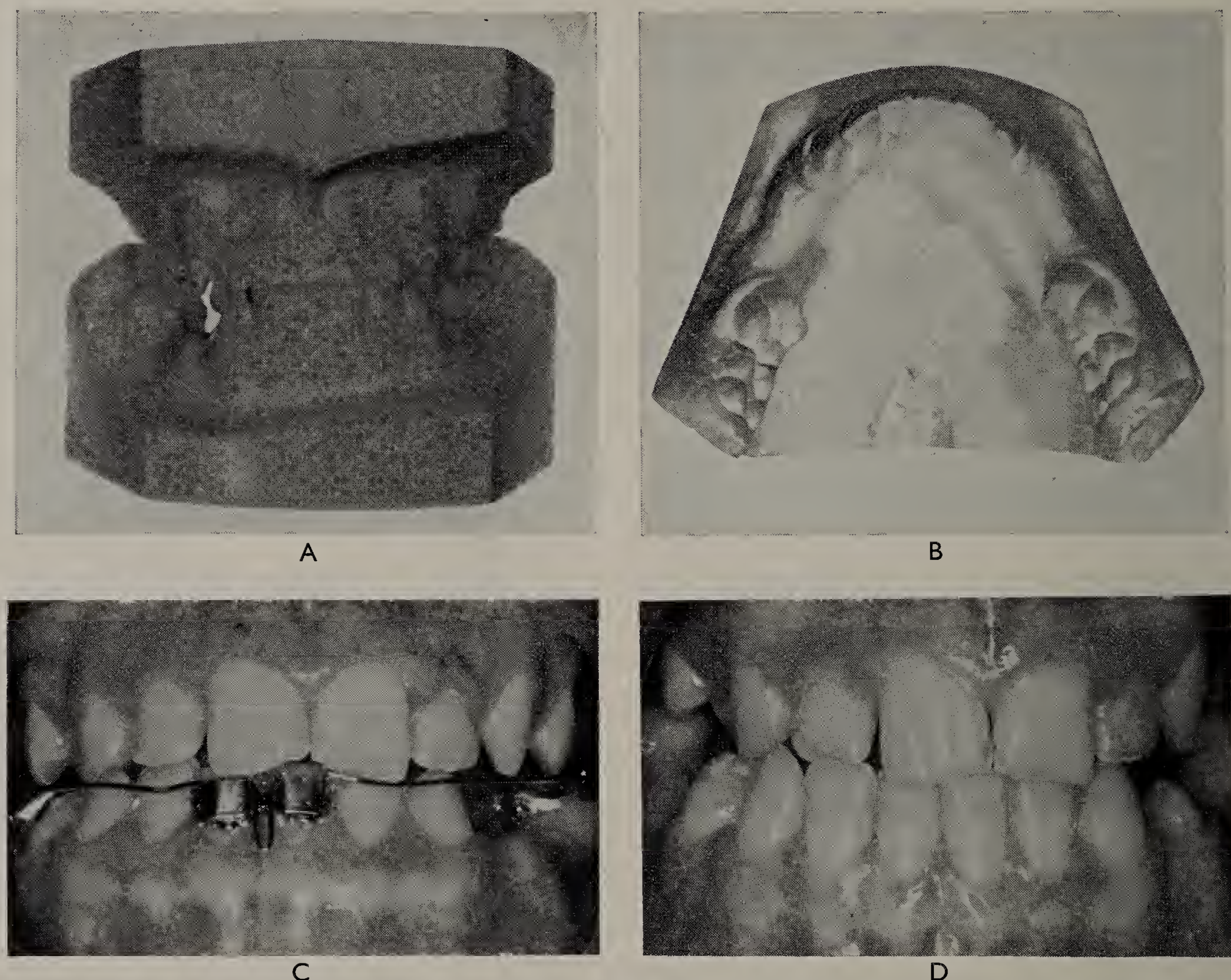


Fig. 4.—A, Study models of *Case* 1 in centric occlusion at commencement of treatment. B, Lower arch showing rotation of lower first molars. C, Incisal relationship after 4 months treatment. D, Incisal relationship 4 months after removal of all appliances.

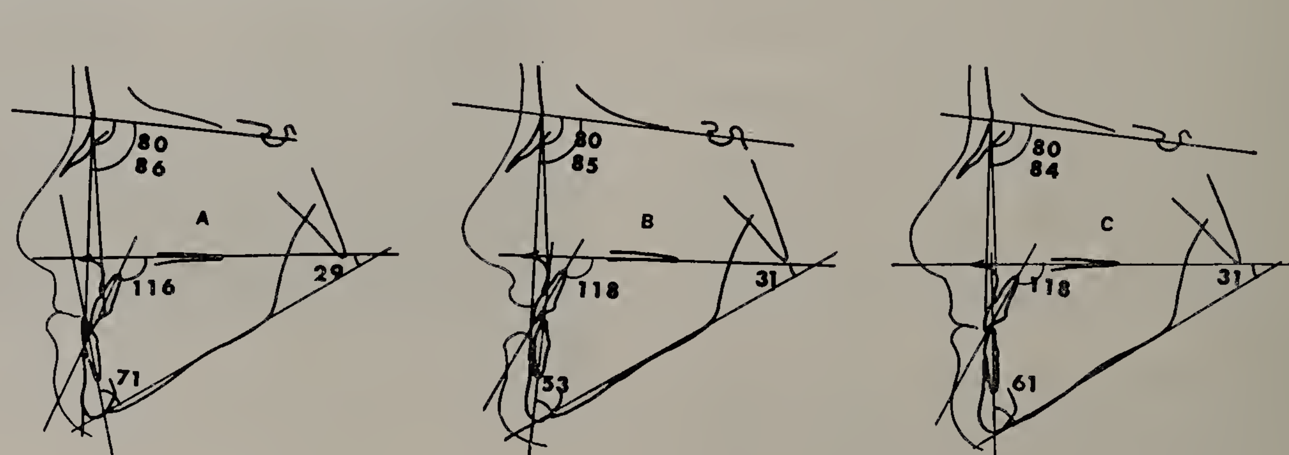
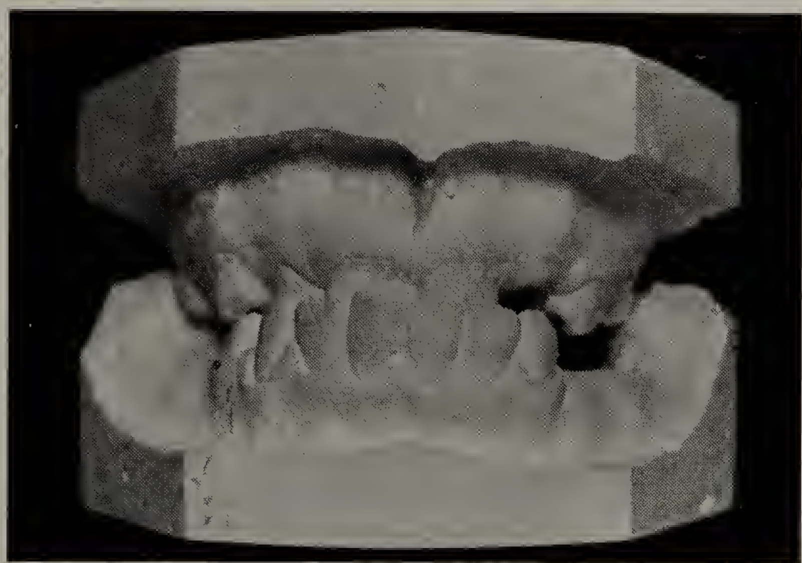


Fig. 5.—Tracings from cephalometric radiographs of *Case* 1. Diagram A at commencement of treatment. Diagram B at the end of treatment 4 months later, and diagram C 4 months after removal of appliances.

Seven cases have been treated with this appliance to date with encouraging results. In each case an upper removable appliance was fitted to free the incisor occlusion by means of buccal blocks. A screw was incorporated to procline the upper incisors, although this was not used with any real effect in the cases treated.



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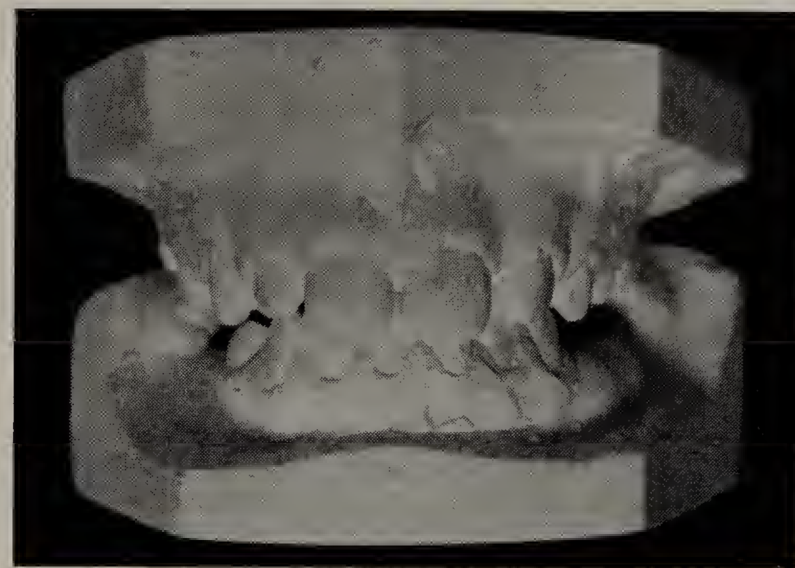

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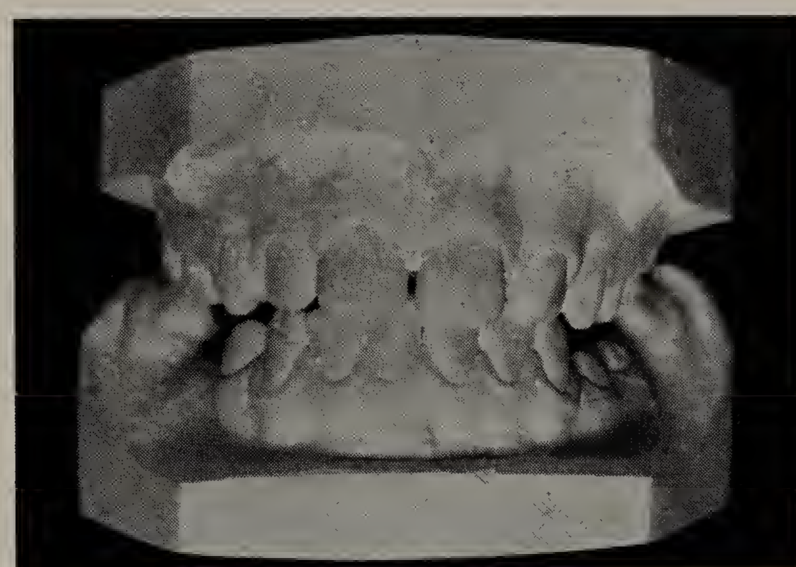

C

Fig. 6.—A, Study models in centric occlusion of *Case* 2. B, Incisal relationship at the end of treatment. $\underline{2|2}$ are missing. C, Incisal relationship 3 months after removal of appliances.

CASE REPORTS

Case 1

Male aged 12 years, 2 months at commencement of treatment.

Clinical Features

The incisor occlusion was Class III on all four incisors (*Fig.* 4). The patient could just achieve an edge-to-edge incisor relationship. There was no displacement of the mandible when passing from rest to centric occlusion. The patient had a definite Class III skeletal pattern with an ANB angle of $-6°$ which is outside the one standard deviation described by Mills (1966) in his series. The upper incisors were proclined and the lowers retroclined. The body of the mandible appeared excessively long. This assessment was substantiated by the presence of ample space in the arch despite evidence of forward drift of the first molars which were rotated mesiolingually (*Fig.* 4B).

Treatment

An upper removable appliance was fitted (29 Nov., 1968) and 1 month later the lower free sliding arch. After 4 months treatment (18 April, 1969) the reverse overjet was corrected and the upper removable appliance left out (*Fig.* 4C). The lower appliance was removed 1 month later (28 May) at which time a definite increase in overjet was established. This soon relapsed to leave a somewhat reduced overbite and overjet (11 Oct.). Cephalometric radiographs showed that during treatment the lower incisors had been retroclined 18° (*Fig.* 5). The upper incisal angulation had scarcely altered. Subsequent to the removal of the appliance the lower incisors proclined to leave an overall retroclination of 10°.

Case 2

Female aged 12 years, 3 months at commencement of treatment.

Clinical Features

This patient again had a complete Class III incisor occlusion (*Fig.* 6A). The patient had a moderate Class III basal relationship. The upper and lower incisors were at a reasonably normal angle and an edge-to-edge incisal relationship could be achieved. In the lower arch the first molars had been extracted with resultant spacing. In the upper arch the lateral incisors were missing. At the time of initial examination the upper right deciduous canine was present, but by the completion of treatment the permanent canines had erupted into good relationship with the central incisors.

Treatment

It was decided that undue proclination of the central incisors would lead to the creation of a diastema because of the absence of the lateral incisors. The main object of treatment was therefore to retrocline the lower incisors. Treatment was, as with the previous case, commenced by fitting an upper removable appliance to free the incisor occlusion (21 Jan., 1969). Three weeks later the free sliding arch was fitted (13 Feb.). The upper removable appliance was left out 5 months after treatment had commenced and after a further month (16 July) the lower appliance was removed. The total treatment time was 6 months.

At the end of treatment an overbite and overjet were established slightly in excess of normal (*Fig.* 6B). This relapsed (16 Oct.) to an overbite and overjet slightly less than normal (*Fig.* 6C).

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CLIFFORD, J. (1965), *Trans. Br. Soc. Study Orthod.*, 29.
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— — (1970), *Dent. Practnr dent. Rec.*, **20,** 183.

DISCUSSION

The President asked whether Dr. Atherton had noticed, in either of the patients mentioned, whether there had been a family tendency to pre-normal occlusion or whether he had suspected a postural pre-normal occlusion.

Dr. Atherton, in reply, said in the first case the position was not of postural origin. The patient had had a very definite Class III skeletal pattern. He did not know of any familial tendency.

The second case had perhaps had a very slight element of postural incisor relationship. This too had been a patient with a definite, but less marked, Class III skeletal pattern.

Mr. C. C. Knowles had noticed that, in the first case, the centre line had been deviated over to the left-hand side, compared with the upper. That had been on the side on which the lateral had relapsed. Did Dr. Atherton think that this was related to the relapse which had taken place later?

Dr. Atherton was interested that Mr. Knowles should have picked this out. The centre line had been deviated, but there had been no molar cross-bite, which one often associated with a deviation of the centre line. The centre line had remained deviated at the end of treatment and was probably related to the relapse.

Professor Leighton said, in connexion with the deviation in the first case, that this relapse had occurred on the side which he would have expected not to relapse. He would have expected the relapse to have involved the canine. In this case, however, it had occurred between the upper and lower lateral incisor.

He asked if this would have been avoided if the laterals had been banded as well as the centrals.

Dr. Atherton replied that this had been one of the most severe cases he had dealt with and had had any success. He had been relieved to achieve what he had achieved, expecially with a patient who was not the best of attenders (though, he added, he had looked after his mouth very well).

It was another possibility, but he had not pursued it.

Mr. D. G. Huggins asked Dr. Atherton why he took the arch back from the central incisor, level with the occlusal plane, rather than going into the sulcus—after the fashion of Clifford.

By taking it straight back, he felt Dr. Atherton was exposing it to great masticatory forces, thus leading to damage.

Dr. Atherton, in reply, said that in both the upper and lower arches he aimed to retract the lateral incisor as well as the central by catching the lateral with the arch as it passed towards the molar region. Thus it was undesirable to take the archwire right into the sulcus.

Mr. Clifford pursued a different policy. He took the central incisors back first, leaving the laterals outstanding and then brought the laterals back. It was a different, but equally valid technique.

Mr. L. A. Usiskin asked if Dr. Atherton had found, in any of his cases, deformation of the wire between the incisors and molars due to mastication.

He asked for some idea of the advantages of the appliance described by Dr. Atherton over the simple removable appliance or other forms of simple fixed appliances.

Dr. Atherton replied that he had had some trouble with deformation when he had first applied the principle of the upper arch to the lower arch.

It was to be noted, on the first slide, when the end was not in the buccal tube the whole wire was curved. When it was put in the buccal tube it kept that bit below the upper occlusion and therefore did not get traumatized.

He did not commonly use removable appliances in the lower arch; he had had difficulty with these, although he had had success with one or two. It was a question of comparing it with other fixed appliances.

In the cases in which he had used this appliance he had tended to use it on patients who had lost lower first molars and whose lower premolars had not yet erupted, therefore one had a limitation in the teeth which one could band. In this instance the appliance worked excellently, because one could bring the second molars forward at the same time as one was retroclining and bringing the lower incisors back. If one had a full lower arch and one were taking out lower fours, then a different technique could be used.

Mr. J. R. Pettman pointed out that one of the things which gave stability after treatment of a reverse incisor bite was an overbite. Did Dr. Atherton consider his appliance might reduce the overbite in any way?

Dr. Atherton said he had had Mr. Pettman's point put to him before. One of the odd things that seemed to happen in practice was that one got a very good overbite.

One reason for this appeared to be the tendency for the appliance to retrocline the lower incisors to an angle parallel to the uppers. Thus the upper and lower incisal segments were able to slide past each other.

Mr. J. Walpole-Day asked if Dr. Atherton had gagged open the bite with his appliance and, if so, were the gags on the molar teeth?

Dr. Atherton replied that he had gagged the bite open with the upper removable appliance, to allow the lower incisors to be free of the uppers.

Mr. J. D. Muir asked Dr. Atherton if he found it desirable to use intermaxillary traction with his appliance. It seemed to him that the length of time needed to treat these two patients was somewhat longer than that needed to treat similar conditions with other appliances.

Dr. Atherton agreed with Mr. Muir, but added that the overjet had been corrected in a shorter time than that in which the case had been terminated. He had, however, gone on to create a definite, positive overjet.

In other cases it could work in a very short time. He had not used intermaxillary traction. He had wanted to keep the appliance as simple as possible and to see how effective it was. It was, in the sort of circumstances he had described in his paper, extremely effective.

THE CONGENITALLY DISPLACED MAXILLARY INCISOR: A DIFFERENTIAL DIAGNOSIS

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When the presenting features of two clinical conditions are similar and the aetiology, treatment, and prognosis markedly dissimilar, the importance of distinguishing between them at the diagnostic level is of prime importance.

That two such clinical conditions should exist in orthodontics and not have been subject to scrutiny is surprising at first inspection, but may be explicable on the grounds that one of the conditions is little known in comparison with the other. It is perhaps because of this that little attention has been paid to the problem in the literature, and perhaps the more important to bring it to a wider notice at the present time.

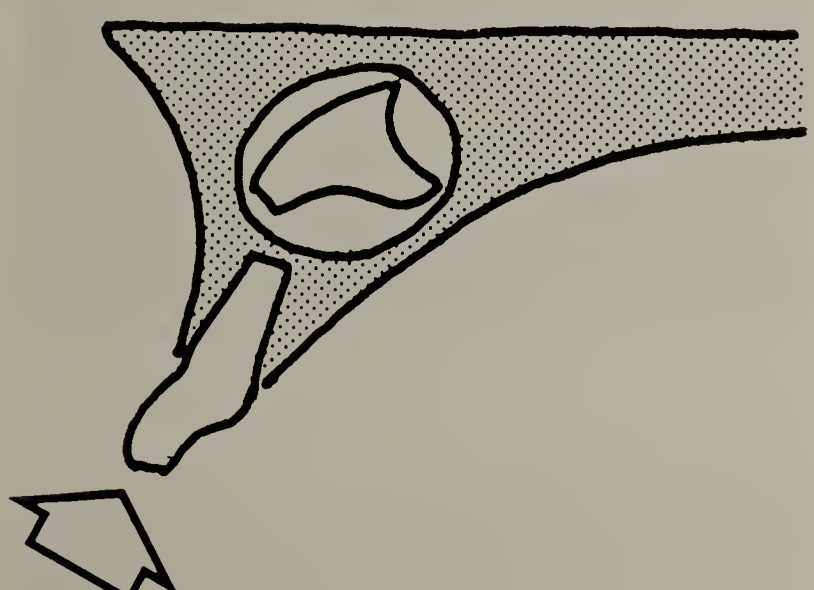

Fig. 1.—Suggested mode of transmission of trauma to unerupted developing central incisor via deciduous predecessor.

The two conditions that it is submitted need to be distinguished are the congenitally displaced incisor and the dilacerated incisor.

The present paper is written in an attempt to draw attention to the similarities and differences between these conditions and to indicate where possible the features that may assist in their differential diagnosis.

It is proposed to deal with the more commonly known condition first.

THE DILACERATED INCISOR

Aetiology

The generally accepted view of the aetiology of this condition is that a deformation of the developing central incisor occurs as a result of transmitted trauma from a blow to the deciduous predecessor (*Fig.* 1). This causes a change in the axial inclination of the crown of the unerupted central incisor which appears to rotate upwards around the cellular and highly vascular dentine papilla. Death of the permanent tooth does not usually result and the root tends to continue developing along its original axis; the resulting tooth, when fully formed, has a marked change in its longitudinal axis on the radicular side of the

Fig. 2.—Lateral X-ray view of extracted dilacerated incisor showing shortening and deformity of root. Terminal root canal at right angles to axis of crown.

Presented at the meeting held on 8 December, 1969.

amelocemental junction (*Fig*. 2). The result of this aberrant formation is a failure of the tooth to erupt, since the axis of the crown is inclined in one direction and the axis of the root in another.

It is possible for the sequence of events described following trauma to occur for only a short time in the developmental history of the central incisor, since it is only at risk when the incisal edge of the permanent central incisor forms a close relationship to the root of the deciduous predecessor. An inspection of *Fig*. 3 shows the situation at 3½ years when the permanent central incisor is still palatal to the deciduous incisor. The deciduous incisor then resorbs to allow the permanent tooth to assume a more labial position in the arch and the permanent incisor passes into the close relationship already discussed. This may be seen in *Fig*. 4, which in this case occurred at 5½ years. It is possible that with the wide degree of variation between individuals this relationship may be reached either earlier or later, but in each individual it would perhaps represent only a short period during which the damage of the type discussed could occur.

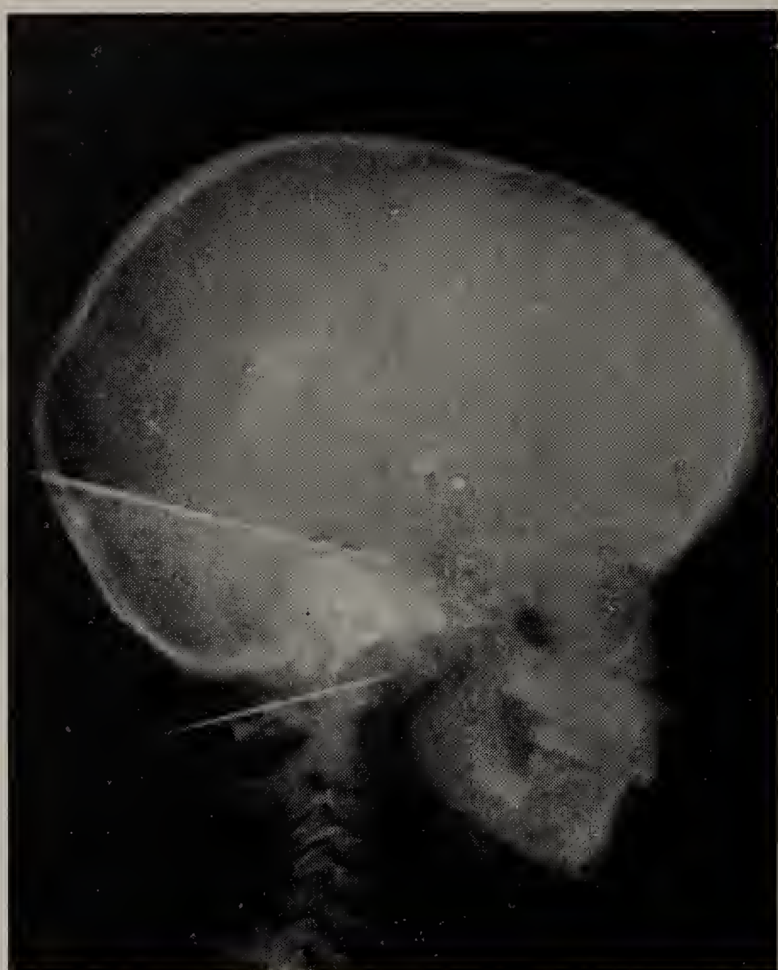

Fig. 3.—Lateral skull film of child aged 3½ years showing position of developing incisors on palatal aspect of deciduous incisors.

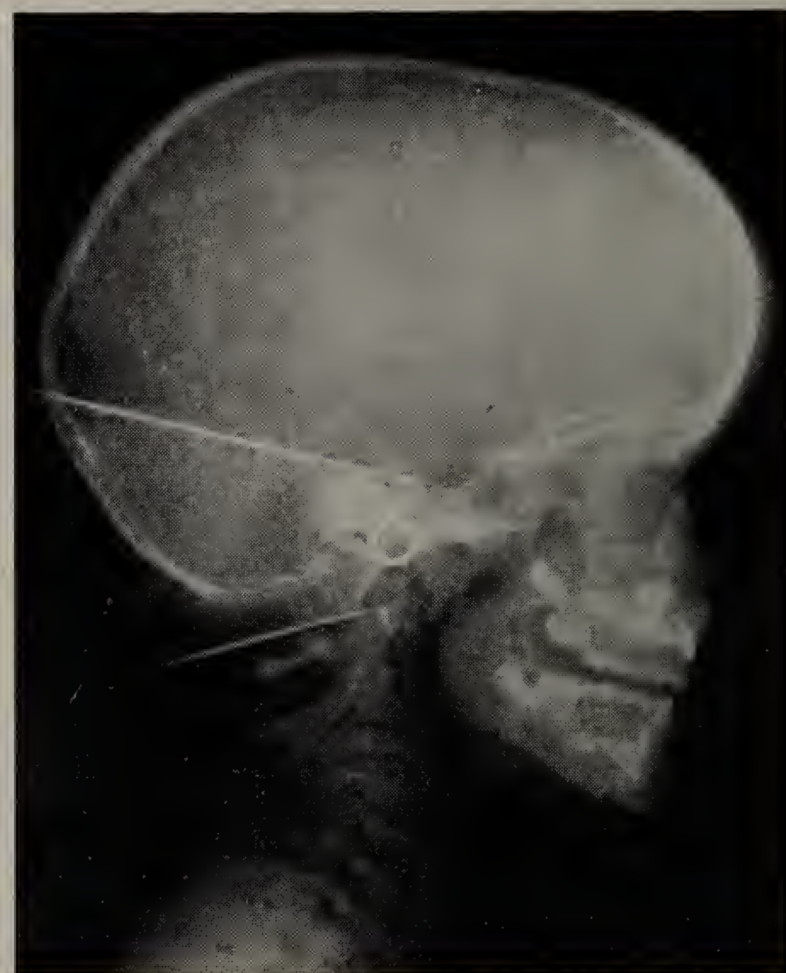

Fig. 4.—Lateral skull film of same child shown in *Fig*. 2 at age of 5½ years, showing change in relationship of permanent central incisor to root of deciduous incisor.

History

There is usually a clear traumatic episode involving the deciduous incisors in the late preschool or early school years. The deciduous incisor is usually traumatized so severely that it is impacted up into the alveolus and may disappear entirely. After the swelling and immediate signs of inflammation have abated it usually re-erupts into the oral cavity. At this stage it is usually non-vital and may be extracted. The contralateral central incisor erupts at the usual time and it is only when some further time has elapsed following the eruption of this tooth that advice is usually sought with a regard for the still unerupted incisor. A connexion is not always noticed by the patient between the traumatic incident and the non-eruption of the incisor.

Clinical Appearance

The deciduous incisor is usually missing, although its remains may still be present and non-vital. The unerupted permanent central incisor may be palpable high in the buccal sulcus above the level of the mucosal reflection but it is not usually very prominent. It is the undersurface, i.e., the palatal aspect of the crown of the incisor that is palpated or the bone covering this surface. It is not usually possible to palpate with any degree of confidence the incisal edge of the unerupted tooth.

Radiographic Appearance

In view of the small number of clinical signs that may be elicited, reliance in most cases will be placed on radiographic investigations and appearances.

1. *Intra-oral View*

This shows the crown of the unerupted incisor in an ' end-on ' view or an inverted position. Careful inspection of the film usually shows the root outline arising from the upper margin of the crown outline and projecting a short distance upwards. The root outline is usually faint and rather short and appears commonly to be at right angles to the longitudinal axis of the crown (*Fig.* 5).

Fig. 5.—Intra-oral X-ray view of dilacerated incisor showing marked dissimilarity of axis of crown and root.

Fig. 6.—Vertex-occlusal view of dilacerated incisor showing shortened root outline and characteristic target appearance of apex.

Fig. 7.—Frontal X-ray view of extracted dilacerated incisor showing tendency to target appearance of apex when seen in this plane.

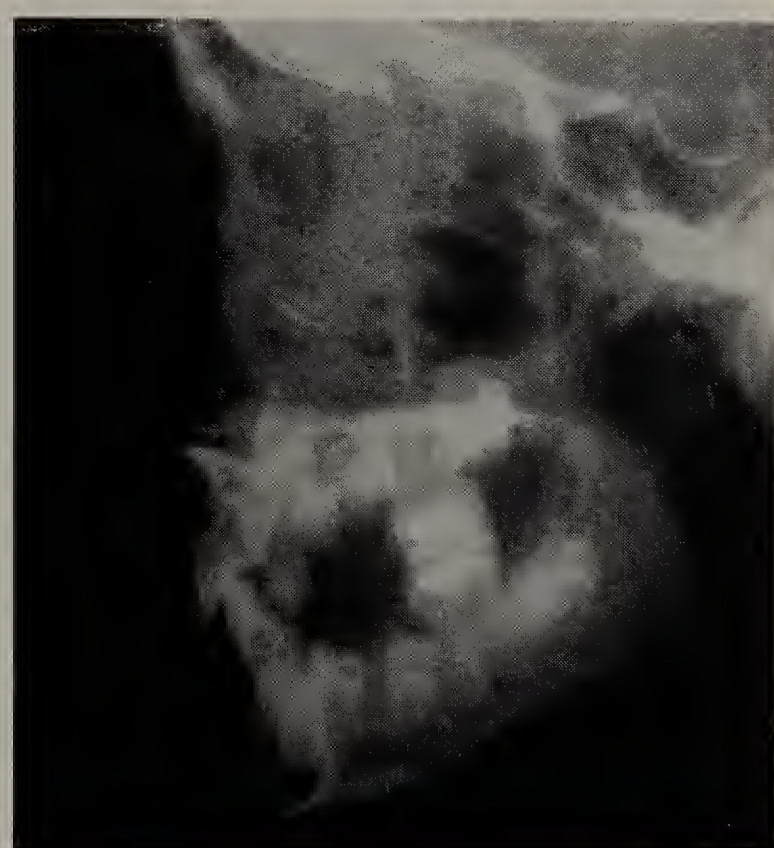

Fig. 8.—Part of lateral skull film of case with dilacerated incisor showing marked angle that incisor forms to maxillary plane. Incisal edge of dilacerated incisor forms close relationship to anterior nasal spine.

2. *Vertex-occlusal View*

This view, taken with the X-ray beam passing down the long axis of the upper incisor teeth, gives perhaps the best view of the unerupted incisor, morphologically speaking.

It shows the crown and root form projected between the normally positioned lateral incisor and contralateral central incisor. Although the detail given by this view is variable, since the X-rays have to pass through many more

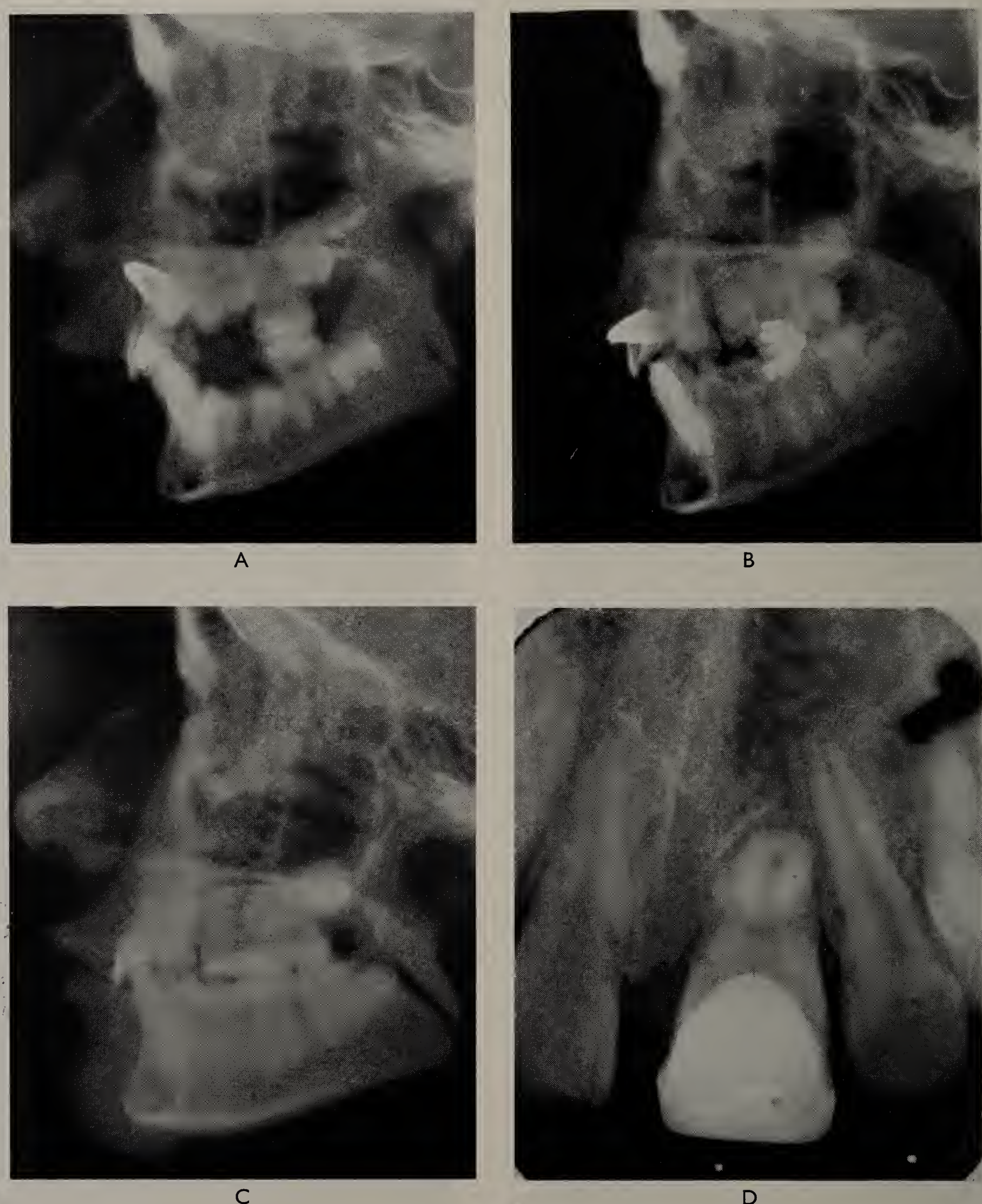

Fig. 9.—A, Postoperative film of case shown in *Fig.* 8. Technique used described by Howard (1966). Stainless-steel crown and ligature for traction may be seen. B, After traction has been applied to correct axial inclination of dilacerated tooth. C, Final film after treatment. Crown of dilacerated tooth has been moved through approximately 110°. D, Intra-oral X-ray view of dilacerated incisor shown in *Fig.* 5 after treatment. Shorter root outline in comparison to other incisors because terminal part of root-inclined labially.

superficial structures, some information with regard to root morphology is usually available.

Since the root, and particularly the apex, of the tooth is not only in a different plane but inclined in a different direction from the crown, the root canal cannot be traced to the end of the root outline (*Fig*. 6). Characteristically, the root outline ends in a target or bull's eye appearance, this representing the upturned apex of the tooth viewed end-on (*Fig*. 7).

3. *Lateral Skull View*

To determine the true vertical height of the dilacerated incisor crown from the occlusal plane, and also its axial inclination, a cephalometric skull view is required. This shows the crown of the unerupted incisor on the labial aspect of the alveolus in the upper incisor region and inclined upwards at a steep angle to the maxillary plane (*Fig*. 8). Although the angle may vary from case to case the angle is always above the horizontal. Further reference will be made to this feature in the analysis.

Little or no root detail is usually seen on the lateral skull film, due to superimposition of adjacent structures.

Treatment and Prognosis

Because the crown and root form such an acute angle to each other the dilacerated incisor would not erupt unaided. Should an attempt be made to bring the crown down into position within the arch by surgical intervention and traction, the root which is labially orientated with regard to the crown may become impacted against the buccal plate of bone of the alveolus before the crown has reached a satisfactory buccolingual position within the arch. For this reason the dilacerated tooth is often extracted. It is possible that if the angle subtended by the root to crown was small then the possibility of bringing the tooth into the arch should be considered. However, no minor degrees of dilaceration have been found, and it is felt that dilaceration when it occurs probably occurs maximally. A treated dilacerated incisor case is shown in *Fig*. 9. The long-term prognosis of such a tooth is not known.

THE CONGENITALLY DISPLACED INCISOR

Aetiology

Little specific attention has been paid to this condition in the literature and it has been usually discussed as a causal factor in the non-eruption of incisors and described as being an ectopic development (Hotz, 1961). No new evidence is being offered by the writer at the present time with regard to the aetiology of this condition, but it is felt that, with the existence of established evidence of ectopic development or congenital displacement of other teeth elsewhere within the arches, this is probably an adequate explanation of the condition.

History

No comparable history of trauma to that given by the dilacerated cases has been obtained in the cases in this group. Although it is probably unlikely that every case will give a completely trauma-free history, trauma of the type and severity discussed earlier is not found.

Fig. 10.—Intra-oral X-ray view of displaced incisor showing continuous outline of crown and root.

Clinical Appearance

The displaced incisor is usually readily palpable high in the buccal sulcus above the level of the mucosal reflection and may form quite a prominent feature. When the upper lip is retracted away from the incisors, the mucosa may be seen to blanch over the unerupted tooth which may thereby be well outlined.

It is often possible to palpate the incisal edge of the unerupted incisor and to get above it.

Radiographic Appearance

1. *Intra-oral View*

Since the technique for taking this view is perhaps a little less standardized than for other views, the information it yields varies. A well-taken film would show the unerupted tooth lying between the erupted central incisor and the lateral incisor and inclined towards the observer (*Fig*. 10). The form of both crown and root

would be clearly visible and form a continuous outline from incisal edge to apical foramen. Although some terminal root deviation may sometimes be apparent, as in the X-ray film shown, at no time is any sharp change in the axis between the crown and root seen.

2. *Vertex-occlusal View*

Once again, as in the dilacerated case, the unerupted incisor is seen as a projected outline between the erupted adjacent teeth (*Fig.* 11). Unlike the dilacerated case, the root outline may be traced from the pulp chamber to apex. The overall length of the tooth appears to be normal.

Fig. 11.—Vertex-occlusal view of displaced incisor showing complete root outline and continuity of root canal from pulp chamber to apex.

3. *Lateral Skull View*

The unerupted incisor crown is clearly visible on the labial aspect of the alveolus in the upper incisor region and appears, in contrast to the dilacerated incisor, to be rather more prominent, i.e., the crown appears to project more labially. This is largely a result of the less steep angle that the crown subtends to the maxillary plane; the angle being below the horizontal rather than above it as in the dilacerated case.

Although it is not usually possible with the normal exposure given for orthodontic cephalometric films to obtain root detail of these teeth, the exposure may be adjusted to give greater penetration, whereupon the entire root outline may be seen (*Fig.* 12). Some loss of detail in the less dense structures will, of course, occur as a result of this.

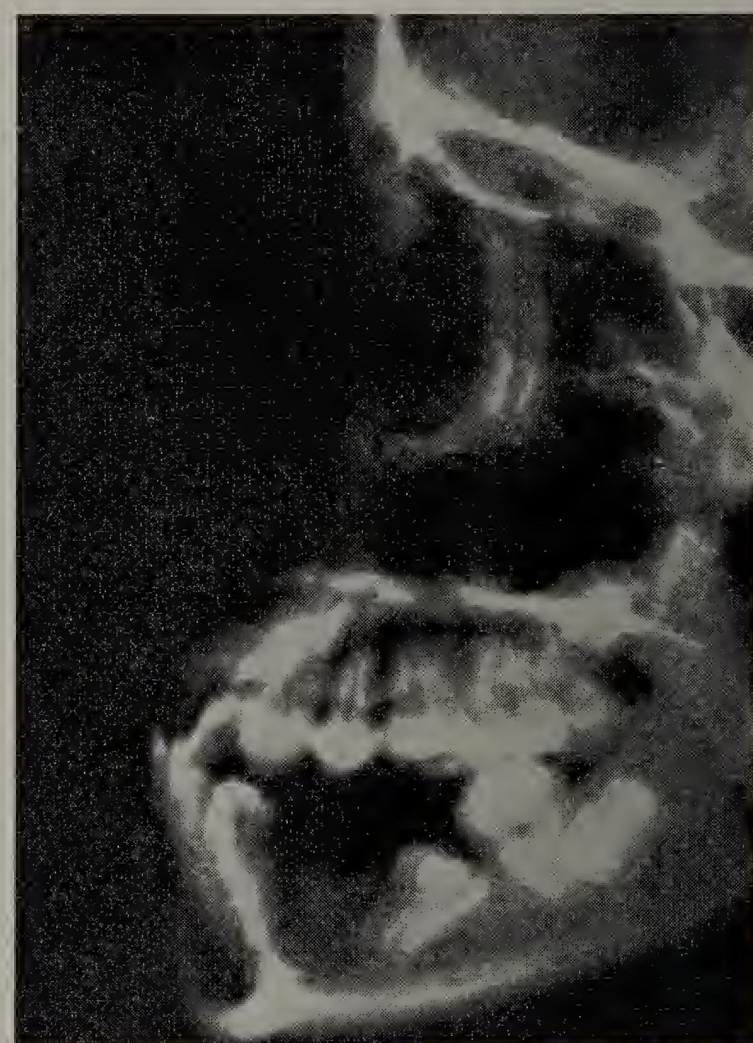

Fig. 12.—Part of lateral skull film showing displaced incisor. Owing to increased penetration to show root outline, crown outline is rather faint.

Treatment and Prognosis

Unlike the dilacerated incisor, which is a deformed tooth, the displaced incisor is essentially a normal tooth that has developed in either the wrong site or, more properly, developed so that its axis of eruption is in the wrong direction. Although some terminal root deviation may be present as a result possibly of development in a site where adequate space has not been present for entirely normal root completion, prognosis for bringing these teeth into position within the arch is excellent. Providing traction can be applied to the unerupted tooth so as to change its angle of inclination from the horizontal to the vertical, eruption then proceeds normally. *Figs.* 13, 14 show X-rays of the case shown in *Figs.* 10, 11 after treatment.

Since this condition has a good prognosis and the dilacerated incisor a poor one, it is suggested that a confusion between the two conditions could lead to the loss of a completely salvable tooth or the unnecessary or abortive treatment of a deformed one.

ANALYSIS

History

Since only the dilacerated incisor cases will give a history of the more severe trauma necessary to cause their condition it might be felt that this would be sufficient evidence in itself to give an indication of the condition. Unfortunately, this is not always so. Children brought up by foster-parents, guardians, or relatives do not necessarily have access to their earlier history, and the memory of parents and grandparents is not always reliable. A positive history will give an indication, but a negative history must not be regarded as entirely excluding the condition.

Fig. 13.—Intra-oral X-ray view of the case shown in *Fig.* 10 after treatment.

Clinical Appearances

The clinical appearance of both conditions may be similar. It is this feature above all others that causes the most concern. An unerupted tooth palpable high in the buccal sulcus which on X-ray evidence is not impeded in its eruption by supernumerary teeth, odontome, or cyst can easily be diagnosed as dilacerated, especially if some traumatic episode, however minor, has been elicited. The danger is more acute if specialist X-ray facilities are not available and too much reliance is placed on an intra-oral view only.

It is, therefore, unfortunate that so little can be gained by a physical examination of the patient. The identification and localization of the unerupted tooth do not in themselves assist in the diagnosis, although the displaced incisor is more easily palpable due to its more prominent position within the alveolus. An easily recognizable incisal edge would tend to indicate a displaced incisor, since a dilacerated incisor is at such a marked angle to the nasal floor that its incisal edge is usually masked by the anterior nasal spine. Should any part of the labial surface of the unerupted incisor be palpable, then the indication is that it is displaced and no alternative diagnosis exists.

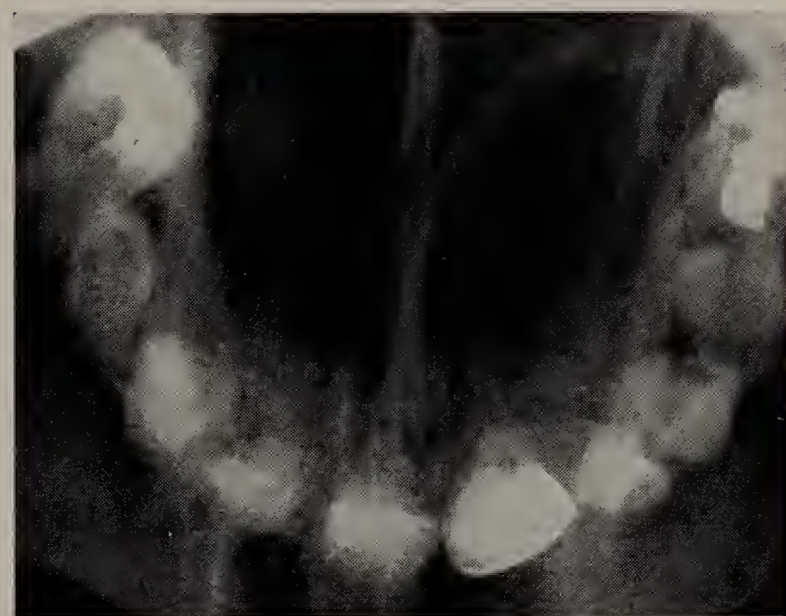

Fig. 14.—Vertex-occlusal view of the case shown in *Fig.* 11 after treatment.

The inability to establish a diagnosis on signs elicited at the physical examination will inevitably mean that reliance will have to be placed on evidence obtained by a radiographic examination.

Radiographic Appearances

The X-ray films used to illustrate this paper have been selected because they show more clearly or more completely the features that it is considered are characteristic of the conditions. Not all X-rays of patients having these conditions will necessarily show all the characteristic features. The presence of one or more of the features alluded to will, however, give an indication of the likely diagnosis, which may be supported by evidence derived from other views.

1. *Intra-oral View*

In order to make clear the differences to be seen in the intra-oral views, drawings have been produced derived from tracings of the X-ray films which have only the essential features included (*Figs.* 15, 16).

Crown and root outline are discontinuous in the dilacerated case, indicating a marked change in the axis of the crown in relation to the root (*Fig.* 15). The crown and root outline in the

displaced case are continuous and in the same plane (*Fig.* 16). Should the angle of the X-ray tube be such that the incisor in the displaced case is seen end-on then no root outline may be seen at all (cf. dilacerated case).

2. *Vertex-occlusal View*

Further drawings have been prepared of these films to emphasize the difference in this plane of examination (*Figs.* 17, 18).

The bull's eye appearance (*Fig.* 17), however, would indicate dilaceration since the appearance is derived from a foreshortened projection of an apex situated at right angles to the film plane superimposed on the root outline (*see Figs.* 2, 7).

Rather less reliable is the shortening effect that the upturned apex of the dilacerated case has on the root outline. The displaced case has, of course, a root outline of normal length.

Fig. 15.—Diagram of typical intra-oral X-ray appearance of dilacerated tooth. Discontinuous outline of crown and root.

Fig. 16.—Diagram of typical intra-oral X-ray view of displaced case to illustrate complete crown and root outline seen on one film.

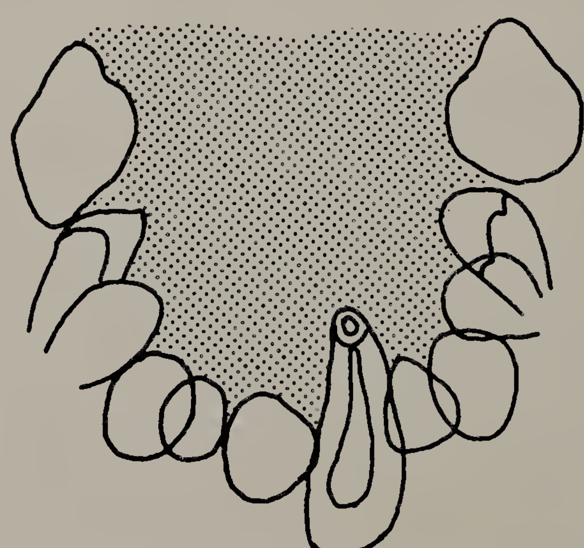

Fig. 17.—Diagram of dilacerated case to illustrate target appearance of apex and root shortening.

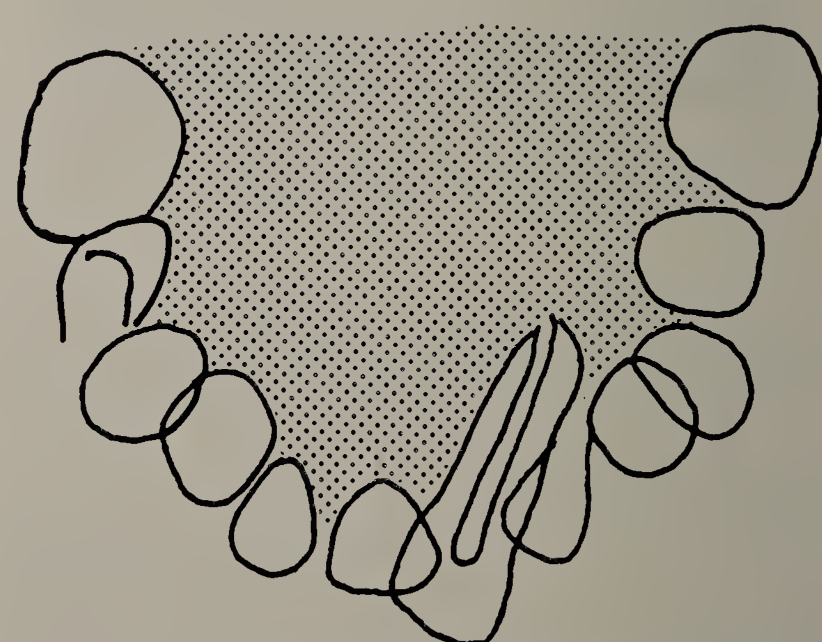

Fig. 18.—Diagram of displaced case to illustrate normal apical appearance, root normal length.

The ability to trace the root canal from crown to apical foramen (*Fig.* 18) makes it likely that the case is one of displacement rather than dilaceration, since the apex of the latter tooth is in a different plane from that of the rest of the tooth (*see Fig.* 2).

3. *Lateral Skull View*

It has already been suggested that the angle of inclination of the unerupted incisor was felt to be an important feature in distinguishing between the two conditions and this has been subject to a closer examination.

METHOD

In order to compare the angle of inclination of the unerupted incisors a method had to be devised that rendered it possible both to measure and compare angles of individual cases. The normal methods used to determine the axial inclination of teeth, for example, the angle of upper incisors to the maxillary plane, could not be used since this relied on the necessity of knowing the position and inclination of the roots of the teeth under examination. In this investigation one group of cases, the dilacerated group, had deformed roots and would be unreliable for this method, and in both groups the root outline coincided with the shadows of many other structures superimposed upon them and would be difficult to determine accurately.

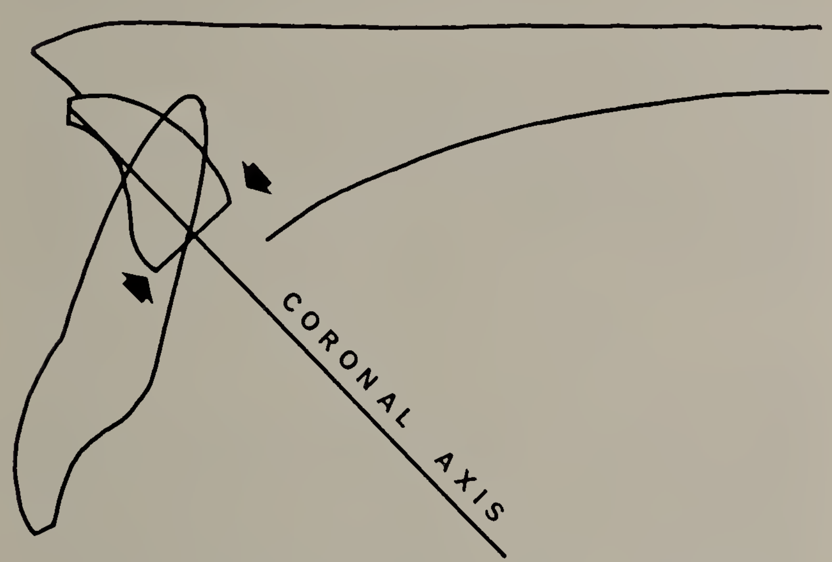

Fig. 19.—Showing method used to determine axis of crown or coronal axis. Arrows indicate amelocemental junction on buccal and palatal aspects of unerupted incisor crown joined by a line which is bisected. Line drawn from centre of incisal edge through bisection is then used to indicate coronal axis.

Since the crown outline was relatively clear in the cases of both groups it was decided to create an artificial axis, the coronal axis, that would be applicable to all the cases.

To determine the coronal axis, tracings were made of the lateral skull X-ray films of the cases in both groups. When tracing the unerupted incisor crowns, the amelocemental junction was marked on both the labial and palatal aspects of the crown outline (*see* arrows in *Fig.* 19). A line was then drawn joining the two points marked and an artificial separation of the crown and root created. By doing so it was hoped that any effect of the deformation of the roots of the dilacerated cases could be excluded from the investigation and undeformed crowns compared with undeformed crowns. The line thus formed was then bisected and a line drawn from the centre of the incisal edge through this bisection. This has been called the coronal axis (*Fig.* 19).

Table I.—Angle Subtended by Coronal Axis to Maxillary Plane

Dilacerated Incisor		*Congenitally Displaced Incisor*	
Case 1	235°	Case 1	180°
Case 2	230°	Case 2	170°
Case 3	219°	Case 3	166°
Case 4	218°	Case 4	155°

The angle subtended by the coronal axis to the maxillary plane was then measured for each case. The results were as in *Table I.* As may be seen, the dilacerated group had the highest coronal angles and the congenitally displaced group the lowest. There was no overlap between the groups.

The dispersion in the dilacerated group of only 17° from the lowest to the highest readings seems to suggest a homogeneity derived from a common causal factor and tends to support the suggestion already made that this condition occurs maximally.

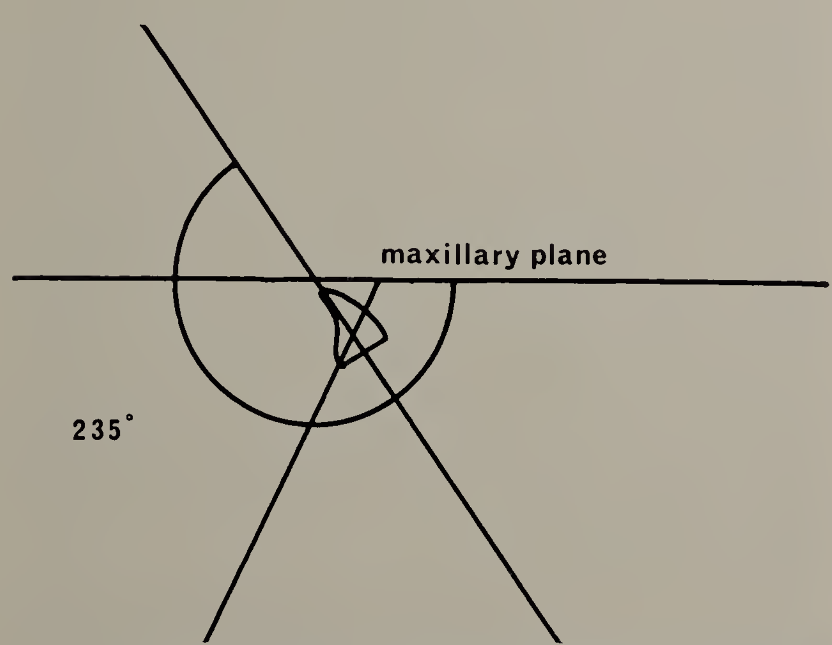

Fig. 20.—Tracing of dilacerated case to show high angle of coronal axis to maxillary plane typical of this type of case.

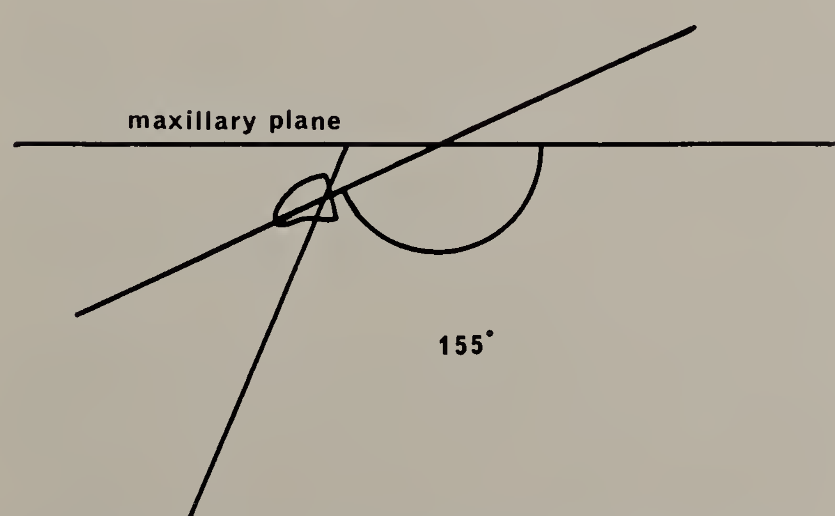

Fig. 21.—Tracing of displaced case to show typically low angle of coronal axis to maxillary plane.

The dispersion in the displaced group was wider, at 25°, and perhaps indicates the operation of a factor under slightly less rigid control.

Although it would be unwise to draw too many conclusions from such a small number of cases, the clinical impression gained that there was a difference of axial inclination of the unerupted tooth in the two groups has been confirmed (*Figs.* 20, 21).

As a hypothesis, it could be suggested, since no dilacerated case has been found near to the horizontal, i.e., 180°, or parallel to the maxillary plane, and only one displaced case approached this figure, that until further evidence is available, parallelism to the maxillary plane may be used to distinguish displaced from dilacerated incisors, those cases subtending an angle of greater than 180° to the maxillary plane being more likely to be dilacerated and those cases subtending an angle of 180° or below being more likely to be displaced.

It is unlikely that evidence drawn from lateral skull material would be used alone, but used in conjunction with evidence obtained from other views, it may help in establishing a definitive diagnosis.

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DISCUSSION

Mr. J. S. Rose thanked Mr. Howard for a very helpful paper. It was often rightly said that it was difficult to differentiate between the displaced and dilacerated tooth. Some of the points Mr. Howard raised would be of great help.

He had mentioned a case which Mr. Rose had presented earlier in the year on the question of whether the tooth was likely to be viable for any length of time. The case to which he referred had been out of retention for over a year and the teeth were still vital and firm. He saw no reason why it should be otherwise—provided that one had reasonable bone, that there was a reasonable periodontal membrane, and that there was no local infection. He saw no obvious reason in such a case why a tooth should not stay vital.

There were many examples of cases where roots had all sorts of various shapes by a natural development. Such teeth lasted well into middle and late life—then why not a maxillary incisor which had been moved?

Mr. Howard replied that the patient he had treated had had an accident which had caused dilaceration. It had been an accident-prone child. They had succeeded in getting the tooth horizontal and then she had pushed it up again.

Mr. B. Scheer thanked Mr. Howard for an interesting paper. He pointed out that if the apex of the primary tooth came as close to the buccal aspect of the permanent crown as had been indicated, it would retrocline this tooth much more easily than normal.

Had Mr. Howard, in the case of the dilacerated incisor, measured the angle of the root and compared it with its contralateral tooth? If so, what had been the result?

Had Mr. Howard seen any cases in which the crown or the tooth had been dilacerated palatally rather than buccally? If so, had he any comments to make on that?

Mr. Howard replying to the question of whether he had compared a dilacerated tooth with a normal one said that he had not. He had the one that had been taken out but not the one left in. X-rays gave a great deal of information but if one had the dilacerated tooth in one's hand one could measure quite accurately.

Regarding the second question, he had not seen any case where dilaceration had occurred in the way described by Mr. Scheer. What probably happened if the central incisor was palatal to the A was that the A became impacted, possibly on the labial side of the tooth.

The case he had shown had had limited fracture of the alveolus, rather as if a wedge had been driven up within a piece of wood, fracturing it. There was a good, curved outline on the labial surface of the incisor. He could not imagine a pushing back; it might happen, but he had not seen it.

Professor B. C. Leighton added his congratulations to Mr. Howard. It had occurred to him, when Mr. Howard had been discussing the effect of a blow on the root of the deciduous tooth on the permanent tooth, that it was necessary for that permanent tooth germ to be rotatable in its follicle. It would be necessary for this to occur in a fairly short period, between the time the permanent incisor moved forward over the deciduous tooth root and the time when its root was so well-formed that it could not rotate in its socket. This theory had rather been spoiled by one or two of Mr. Howard's X-rays, showing a substantial proportion of root in line with the crown.

Could it be that the bend in the root occurred, not immediately the blow occurred, but subsequently, when there was some difficulty in the limited confines of the follicle, so that the root started straight and then became curved when it encountered the periphery of the follicle?

He questioned ' very gently ' Mr. Howard's suggestion that the displaced teeth were congenitally displaced. One assumed that they were congenitally displaced, but had one any evidence of this? Was there no history of trauma in these cases, at perhaps a different age? Was there no other possible explanation?

Finally, he wondered if, having extracted these displaced teeth, Mr. Howard found any other characteristics in their morphology? At least one had been an invaginated tooth; was this common, he asked.

Mr. Howard replied that, regarding the development of the root, he had not been quite sure of the histology. When the crown of the incisor was rotated in the follicle, as Professor Leighton had said, it had to occur at a time when there was no root formed. The crown rotated to the maximum extent within the limit of the bony cavity, within which it found itself. It

rotated around the dentine papilla which did not die if it was pushed off its vascular bed.

He had never seen a case go from start to finish where he had observed the trauma, followed it through, and said ' this happens because that occurred '—it was all inference. He had said in the paper that ' the generally accepted view was that, etc; ' it was not necessarily his view, because he was not certain. He accepted this because he had no alternative explanation.

The bend appeared to occur later on because of its position on the root, but could it not be, when the crown was rotating within the follicle—whatever cellular element went to make up the root—that they became strained into a new shape? It looked as though it occurred chronologically later but, in fact, the bend had already occurred at the cellular level and it was going on forming root at the rate and direction determined before the trauma.

He had been asked if the incisors had been congenitally displaced. He rather assumed so because, again, he had no other explanation for them. One did have other teeth congenitally displaced. He had in mind transpositions of teeth. This must occur at an early stage, probably at the time of cellular differentiation of the teeth; there is a little disorientation of the tooth germ and it pointed the wrong way, as it were. He felt that it did not require very great imagination for one to see that this could take place; it could occur anywhere within the arch. He added that one found sixes upside-down, for no very good reason. One said that they were ' congenitally displaced ' because other teeth could be congenitally displaced. The incisor could be one of them. He did not know the causes; it was a ' sheer bit of bad luck, congenitally speaking '. The cells happened to differentiate at a different rate and turned the follicle round. This was an area in which there was only speculation at the present time.

Professor B. C. Leighton felt that the speculation arose because this was an area particularly exposed to trauma—and it occurred unilaterally.

Mr. Howard replied that it was very difficult to find a child in whom no trauma had ever occurred. Children tended to bump into things and fall about. If one were looking for causation, ' mummy can always remember that he walked into a door '. In most of these cases, particularly the dilacerated cases, the trauma had been quite severe. They had had to seek professional advice immediately at hospital. It was caused very often by the ordinary milk bottle—they held the bottle and they fell on it.

Mr. B. Scheer said that when he had asked Mr. Howard if he had seen any of the teeth displaced palatally it was because he had seen cases himself. Mr. Howard had said that the teeth were usually hit upwards and that therefore the crown was displaced upwards and outwards. There were cases which, rather than having been dilacerated, perhaps because trauma may have occurred a little later, the primary tooth was damaged at a later stage of development; an area of hypoplasia was found on the labial surface of the permanent tooth. One could have the impact occurring on the labial rather than the palatal surface and would therefore expect, occasionally, to have rotation in the other direction than that he had suggested.

He wondered whether it was a case of ' all or nothing ' as Mr. Howard had suggested. For instance, the whole idea of these teeth being pushed into a socket was that they behaved like a ' wedge ' being pushed into a crack. It was suggested that there was a time when they just popped through the crack. He wondered whether this did happen and whether, if the trauma occurred at the right time, less trauma might be needed to produce such damage. Perhaps a complete movement of the tooth follicle, rather than just of the crown, occurred at a time when the crown was not quite so well developed.

Mr. Howard replied that he was still unhappy about the palatal displacement. It could occur early. The only way he could see it occurring in such a way would not be from trauma. He had seen crowns of central incisors displaced palatally, not through trauma, but due to the death of the deciduous tooth, a dental cyst arising, and this went much more with hyperplasia. He had not taken any X-rays to establish this but there had been something odd in the appearance; he had not taken the tooth out to confirm it. The whole follicle moved up; the follicle occupied the total internal dimensions of the crypt.

Mr. Scheer said that he was implying it might rotate.

Mr. Howard asked if this had not been the point he had made: that it rotated within the crypt?

Mr. Scheer said that he was suggesting that, if the whole follicle rotated, the root, crown, and everything would rotate.

Mr. Howard said that one would still need a fair amount of trauma. The amount one had in dilacerated cases was quite severe. It would be very unusual for this to happen unnoticed. Although on X-ray the relationship looked quite close, the teeth were separated by some distance, by some millimetres. The A had to travel some distance before it contacted the tooth; this was the limiting factor to the permanent teeth turning upwards. Whatever the traumatizing agent was, it went up and, having hit the A, it pushed it up so that it disappeared completely. The resistance then was such that the bottle, or whatever it was touched other things; it contacted the alveolus and might, in a severe injury, involve the alveolus and displace it. He had not seen this, however. It usually stopped there and that was the limiting factor. It was an interesting field for observation.

Mr. J. P. Moss said that, regarding the displaced incisor, he had had two cases recently where he had noticed, on exposure, that the follicle had been rather fleshy. Twice he had sent this for histological examination and it had been returned with the comment ' melanoameloblastoma '; this tumour had been extremely small but had perhaps caused the delayed eruption of the upper central incisor.

Had Mr. Howard noticed in his cases whether he had had a rather enlarged follicle and had he had it examined histologically?

Mr. Howard agreed with Mr. Moss. In quite a few of the cases the follicle was enlarged. The technique which he used to apply traction involved putting a stainless-steel crown inside the follicle of the tooth and closing it up. He had not ' cut any bits off ', and could not say what the histology was.

He asked Mr. Moss what the appearance had been, apart from fleshiness. Had there been anything else which was characteristic?

Mr. Moss said that there was not. It had not looked quite like fibrous tissue but it was enlarged.

Mr. Howard said that he would look out for this. This was all he could say.

A CEPHALOMETRIC STUDY OF THE ERUPTION OF LOWER THIRD MOLARS FOLLOWING THE LOSS OF LOWER SECOND MOLARS

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INTRODUCTION

The problem of the impacted lower third molar is constantly in the mind of the orthodontist as his case reaches completion, with well-alined teeth in upper and lower arches. The lower third molar has been labelled the cause of lower incisor imbrication in late teenage patients, either in cases which have received orthodontic treatment or where the arch was previously well alined.

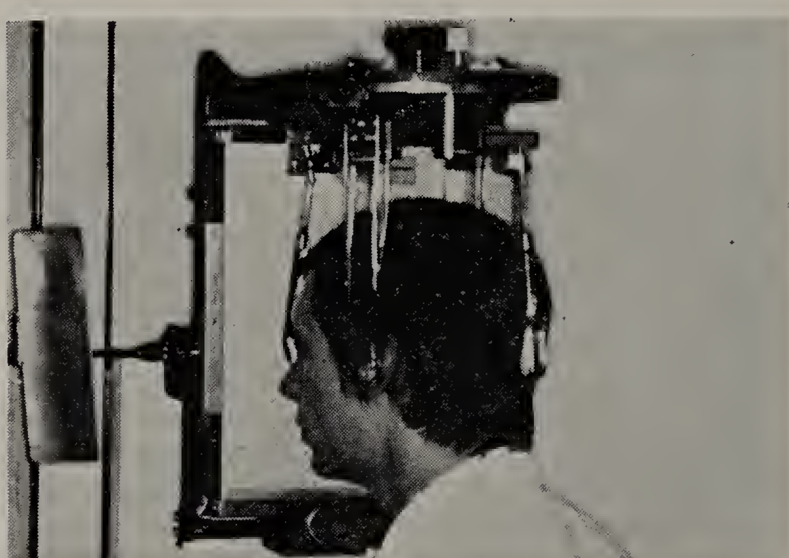

Fig. 1.—Illustrates a patient seated in the cephalometer.

There is some doubt as to whether cases will deteriorate due to pressure from the lower third molar eruption and also as to which third molars will erupt if disimpacted, although Henry and Morrant (1936) described a little-used method for assessing the likelihood of eruption of developing lower third molars.

Review of the Literature

The presence or absence of third molars was reviewed by Hellman (1936); the effect of extraction of lower second molars on third molar eruption has been discussed by Henry and Morrant (1936), Smith (1957), Breakspear (1966), Cryer (1967), and Wilson (1966). However, these authors were unable to discuss their results using standardized radiographic views. Fleischer Peters (1963) indicated the value of the orthopantomagraphic view in assessing third-molar development, although this author did not present a series of cases to demonstrate the use of this standardized approach. Barber, Pruzansky, and Kindelsperger (1961) discussed the use of rotated lateral cephalograms in assessing development of the dentition, and it could be that this view of the third molar will prove to be of value in assessing the potential of this tooth to erupt, in order to become a useful member of the dentition.

The Present Study

The aim of this study was to use standardized serial cephalometric X-rays to show the initial position and subsequent eruption pattern of the lower third molars, following the extraction of the lower second molar.

METHODS AND MATERIALS

Patients were seen during examination for an orthodontic assessment. Patients having lower-arch crowding, sound teeth, and third molars present with their crowns forming were considered for inclusion in this study. The average age of the patients was 13·5 years and there were 7 male and 13 female. Thirty-five teeth were examined radiographically. Films were taken before, 8–10 months (32 teeth), and 20–24 months (3 teeth) after extraction of the lower second molars. Lateral skull films were also available in order that the skeletal pattern of the patient might be determined. Fourteen had Class I

Presented at the meeting held on 8 December, 1969.

dental base, 4 had Class II dental base, and 2 had Class III dental base. The films were taken in a cephalostat with an anode–film distance of 5 feet, the head being rotated 45° from the true lateral position in order that left and right rotated views might be obtained. The patients were positioned accurately using ear posts and occipital and nasal positioners (*Fig.* 1), the Frankfurt plane being horizontal-parallel with the floor. The films of any one patient were traced at the same time by one of the authors using the same viewing box and sharp pencils.

Fig. 2.—Illustrates radiographic view obtained in order to assess the eruptive path of the lower third molar.

It was considered that the important criteria in this study would be the angle made by the occlusal line of the lower third molar with the lower occlusal plane and the distance moved, both forwards and towards the occlusal plane, by the crown of the erupting tooth (*Fig.* 2).

Points of Superimposition

With standardized technique used and 45° rotation of the head from the sagittal plane, it should be possible to superimpose sequential films or tracings therefrom, using the porion markers to achieve complete coincidence of all anatomical landmarks. The path of eruption of a disimpacted tooth could then be followed. The distance travelled along the eruption path would be dependent upon the time elapsed between the extraction of the second molar and the second X-ray film.

Using the porion markers it was found that anatomical superimposition could not be achieved. The positioning of the head in space was not accurately controlled with the cephalostat that was used. The 45° gradation from the sagittal plane can be measured and achieved, positioning the head correctly rotated about its vertical axis. But the nasal and occipital positioning arms allow variation about the horizontal axis through the porion, resulting in inaccuracies in the Frankfurt plane which had to be estimated. The superimposition of the lower mandibular border and of the premolar and first molar teeth were not found to coincide when the porion markers were superimposed.

Serial Cephalograms

Lateral films superimposed on S point or registration point are satisfactory as they are superimposed in one plane only. The authors found that with the laterally rotated cephalograms attempted superimposition in two planes was not successful if the point of superimposition was some distance from the site of interest.

Tracing Variables

The superimposition of tracings of the lower second premolar and lower first molar and the relationship of these teeth to the erupting lower third molar was found to be constant. The amount of eruption, however, had to be assessed with caution as with a crowded lower arch the extraction of the lower second molar may allow distal movement of the lower second premolar and the first molar simultaneously.

The tracing of the lower second premolar and lower first molars has presented no problem as these teeth are in profile in one plane. However, the crown of the impacted lower third molar is frequently both mesially and also lingually inclined. Its X-ray appearance is, therefore, in some cases three-dimensional, and it becomes a matter of judgement to decide which part of the shadowed outline is mesial cusp and which is distal cusp. These cuspal points were chosen to measure the difference in millimetres between the teeth on consecutive X-rays. They were also the points chosen from which to draw a plane of the occlusal surface of the lower third molar, extended to intersect the occlusal plane drawn through the cusps of the lower second premolar and lower first molar (*Fig.* 3). The angle of this intersection was measured in each case, and as the angle became smaller in the post-extraction cases, so the eruption path of the lower third molar seemed to become more upright. In some

cases the post-extraction angle appeared to increase, possibly indicating forward tilting of the eruption path of the third molar. Where there was a large difference in the two angles the measurement of the movement of the mesial cusp was found to be much greater than that of the distal cusp, indicating that the disimpacted tooth was uprighting its mesial inclined surface as it erupted. The accuracy of the tracing method was determined using the double determination method of Dahlberg (1940). The authors found an error of 2·5° using all cases. By eliminating four cases in which an exceptionally high error was recorded this was reduced to 1·5°.

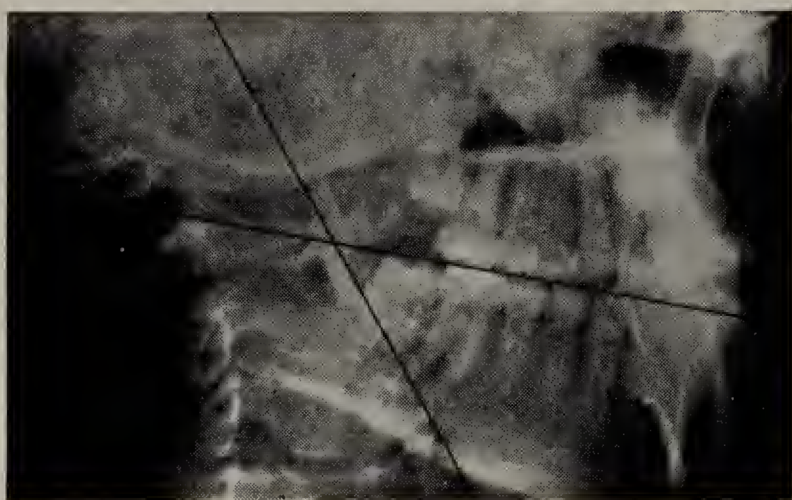

Fig. 3.—Photograph of radiograph to illustrate the planes selected for tracing.

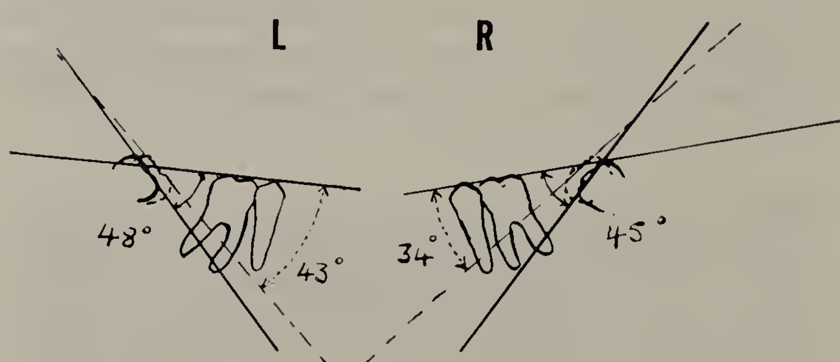

Fig. 5.—Illustrates the angle 8|8 decreasing during 'eruption'; it is felt that this tooth will reach a satisfactory position in the occlusion. The alteration shown has taken place over an 8-month period.

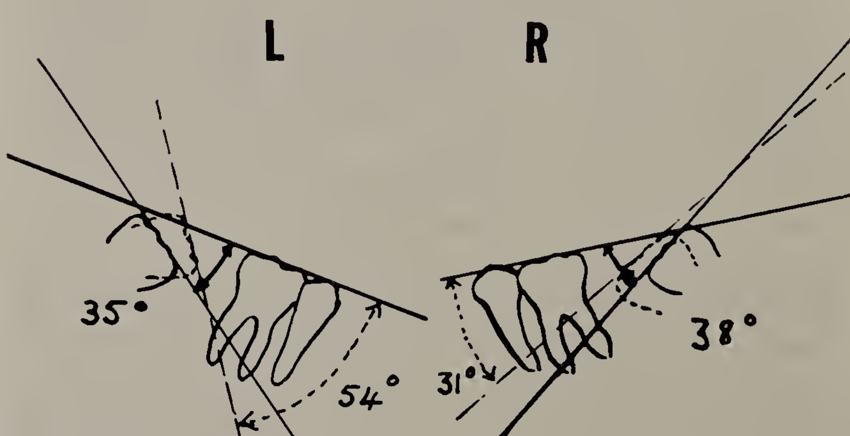

Fig. 7.—Illustrates 8|8 having similar initial position but pursuing different paths of eruption, during 22 months.

RESULTS

Of the 35 teeth observed, 11 showed an increase in angle during eruption; that is, their position became less favourable relative to the occlusal plane. Of the remaining 24, 23 decreased their angle to occlusal plane, indicating a more favourable path of eruption. One case showed bodily mesial movement, that is, without angular change (*Fig.* 4). The illustrations allow closer examination of selected cases (*Figs.* 5–9).

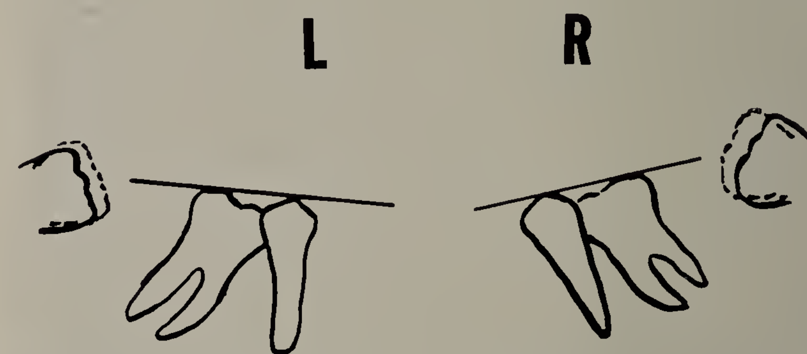

Fig. 4.—Tracing from a radiograph to show bodily mesial movement of the lower third molar.

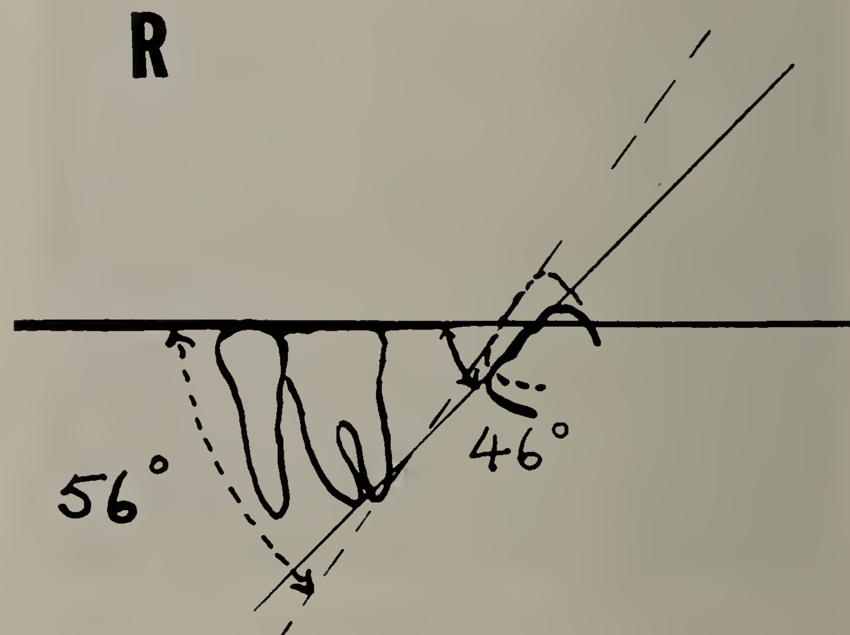

Fig. 6.—Illustrates the angle of 8| increasing, that is, being less favourable for eruption, during 8 months.

This raises the question as to whether initial angulation influences eventual eruption path. A histogram will serve to amplify this point (*Fig.* 10).

In the groups having angulation 20°–29° and 30°–39°, there was only one tooth in each, and on both occasions there was an increase in angle, that is, a less favourable position was reached.

In the group 40°–49° there were 10 teeth, only 1 of which increased its angle relative to the occlusal plane.

In the group 50°–59° there were 12 teeth, 5 of which increased their angle relative to the occlusal plane.

In the group 60°–69° there were 8 teeth, 5 of which increased their angle relative to the occlusal plane.

In the group 70°–79° there were 3 teeth, 2 of which decreased their angle relative to the occlusal plane, and the remaining 1 moved bodily forward.

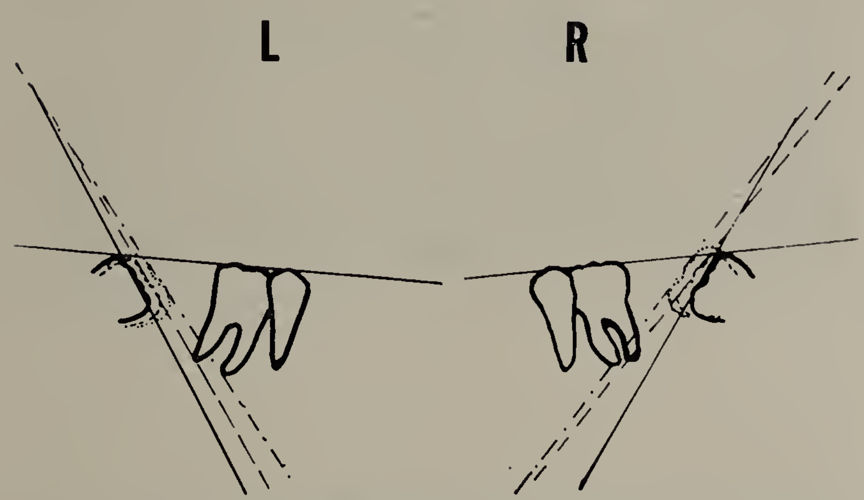

Fig. 8.—To illustrate superimposition of three films over an 18-month period to show continuing decrease in angle of 8|8 to occlusal plane, suggesting that 8|8 will reach a satisfactory occlusal position. Initial angulation 8| 55°; |8 60°.

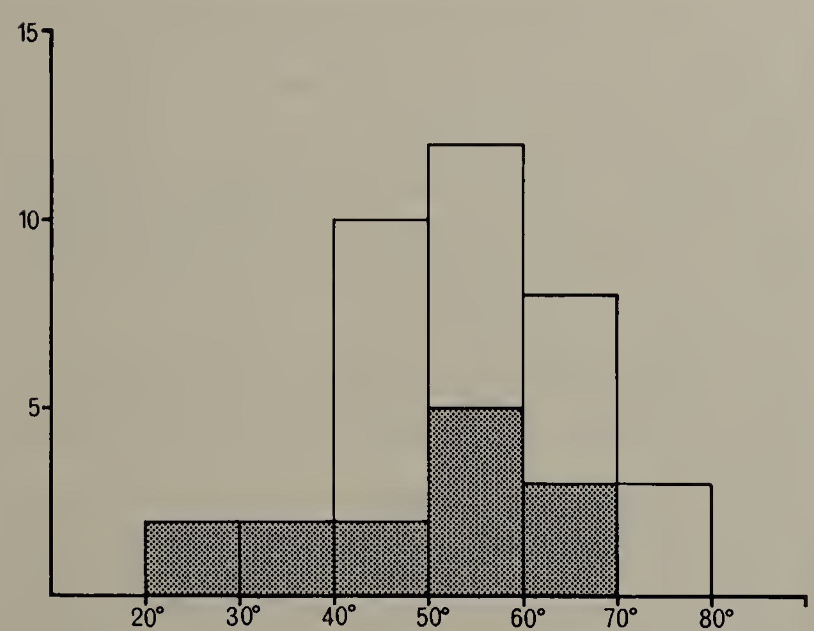

Fig. 10.—Histogram to illustrate initial angulation of the teeth observed.

One may therefore conclude that the teeth most favourable for eruption are those which initially have an angulation of less than 50° to the occlusal plane.

It is difficult to interpret the findings with regard to teeth having initial angulation over 50°, but it would appear from this small number of cases that some teeth will improve their relation to the occlusal plane even though their initial appearance would appear adverse. The second molar would need to have a poor prognosis to encourage its loss when the third molar comes into this category. The amount of alteration in the angulation of the teeth in successive tracings is small in some cases, and it may be that teeth showing these small differences would from casual observation have been classified as erupting on a straight line mesially, as suggested by previous authors.

It should be noted that all cases for extraction were selected jointly by the authors and at the time the angulation of all the third molars was felt to be less than 60°. The fact that 11 teeth had angulation greater than 60° highlights the importance of measuring the angulation rather than relying on judgement.

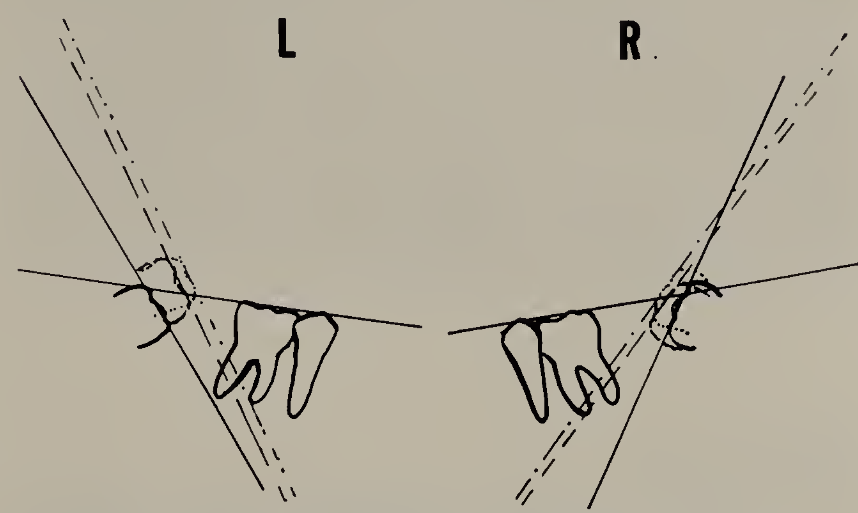

Fig. 9.—To illustrate 8| becoming more favourable and |8 less favourable to the occlusal plane over a 2-year period. Initial angulation 8| 56°; |8 60°.

Regarding linear movement of the teeth, those examined 8–10 months after extraction of second molars showed an average movement of 2·6 mm. Those cases examined after 20–24 months had a linear movement of 4·5 mm. This appears to be an expected rate of eruption, but individual case analysis was disappointing.

There were some unexpected cases, for instance, after 10 months, 6 mm. movement. It was felt that trends in angulation were of more interest and clinical value than linear measurement.

DISCUSSION

It will be seen from the material presented that the patients had an age range of from 11 to 16 years with an average of 13·5 years. The lower second molars were therefore extracted in most cases before the roots of the lower third molars had commenced to form. The survey tends to agree in general terms with Cryer's findings (1967) as regards the eruption path of lower third molars. That is, that they tend to upright on many occasions during eruption and do not pursue a straight upward and forward eruption path as was suggested by Breakspear (1966). However, there are occasions in which the lower third molar would, following extraction of the lower second molar, appear to tip forwards, and it will be a matter of interest to the authors to follow their cases further so that a full report of these and other cases may be made later.

Certain advantages were apparent in the patients in whom lower second molars were extracted, and briefly these may be recorded as good contact points being maintained in the lower buccal segments and relief of mild crowding, especially in the second premolar area. There was no increase in overbite. Appliances were not required to achieve the slight relief of crowding which was possible, and, of course, the third molars were in these cases disimpacted without recourse to surgery. It is hoped that this longitudinal survey will continue and that eventually the prognosis for impacted lower third molars can be accurately assessed using the geometric system which has been demonstrated.

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DISCUSSION

Professor B. C. Leighton congratulated Mr. Huggins on bringing out a most important subject—one of which orthodontists were just beginning to be conscious.

His own experience was that third molars were particularly treacherous in their behaviour. He, too, had experienced cases where two apparently similar molars on either side of the mouth had behaved in diametrically opposite ways following the extraction of second molars.

Had Mr. Huggins noticed in his researches the size of the third molar, he asked. He felt that the larger the third molar, the less the chance of its recovery after loss of the second molar. He had noticed that those which showed spacing between the second and third molars were less likely to recover, and perhaps showed more mesial tilting following the extraction of the second molar.

The survey would be much more convincing in 2 or 3 years' time when the cases had been followed up for a longer period. Immediately after extraction the amount of movement of the third molar was relatively small and the dramatic phase of movement occurred 18–30 months after extraction. The ' exciting phase ' was, therefore, still to come.

Mr. Huggins was not quite clear as to whether the size of the teeth had influenced the situation.

Mr. McBride added that they had not noticed any great difference.

Regarding the spacing between the second and third molar—he did not think that this produced any difference in the path of eruption. They would look at this point. He certainly agreed that the interesting phase was when one reached the 18–35-month period. They had three or four cases in that group. They had completed their radiographs some considerable time ago and they now had patients in the 30-month period of whom they would be taking further films.

Mr. D. D. Di Biase commented that Mr. Huggins had mentioned changes in angulation in the mesiodistal plane. Had there been any changes in the buccal-lingual plane? If so, had these affected in any way the measurements in the mesiodistal plane.

Mr. McBride replied that they had seen some three-dimensional molars and the angulation in the mesiodistal plane might tend to decrease after the extraction of second molars. One would also expect that the angulation in the buccal-lingual plane would also decrease. Tracings of teeth like this were needed over a period of 18–30 months, so that two or three tracings were available in order to differentiate the cuspal movement in these teeth and to see them improve into a profiled instead of a three-dimensional picture.

Mr. F. Allen asked if the extraction of second molars was merely because of the supposed impaction of the third molar, or because of the general orthodontic condition of the malocclusion.

He extracted first molars, on principle, if there was a two-surface Mo or Do. One was considerably concerned with the third molars in following up the cases. The third molars did not get impacted once the first molar was extracted—followed, of course, by orthodontic treatment.

Mr. Huggins agreed regarding the indications for removing the first molar. If first molars were heavily restored these should be extracted in preference to the second molar.

He had been at pains to point out, during the paper, that the lower second molar had been removed when the other teeth in the arch were sound and when there was some crowding in the lower second premolar region. This was where one felt the need to extract a second rather than a first molar.

If one removed a first molar where a quarter of a unit of space was required, it left a considerable amount of space to close; whereas, if one extracted the second molar when the third molar was favourable, appliances were not required, in that the second premolar erupted and there was some movement of the lower third molar mesially.

In reply to a further question by Mr. Allen, Mr. Huggins agreed that they did not extract merely because the third molar was impacted.

Mr. E. K. Breakspear congratulated the authors on their paper. Mr. Huggins had carried the investigation two or three steps further in what was very interesting work. He still had a few reservations, however, as to whether his own ideas might not, in the end, turn out to be a little nearer the mark than at first appeared.

For example, most of his cases had been observed over 5 or 6 years; that might make some difference.

He had taken his X-rays every 18 months or 2 years, for as long as the patient would come.

From the clinical point of view, the occlusal plane was not the one that mattered. The tooth had to articulate with the upper third or second molars, or both, at quite a different angle from the occlusal plane. It was, therefore, the relationship to the upper distal molars that really mattered. That did not stop one using the occlusal plane as the standard, but it was the other one one had to think about.

Many of these cases had crowding and therefore one would expect the first molar to tilt back to some extent, which one very often found in the cases where there was a good deal of crowding. Did Mr. Huggins think this tilting back, or settling back, of the first molar might possibly, in some cases, have altered the apparent occlusal plane, in the particular way in which he had measured it?

Mr. Huggins replied that the tilting distally of first molars influenced the results shown. In future it is the intention to superimpose films accurately on the porion markers. Provided that the technique of taking the films is improved, a satisfactory point of superimposition can be found.

Regarding the lower third molars moving in a straight line mesially, as was said in the paper, this was present in the previous work; but on the views taken on this study it appeared that the teeth were continually changing their angulation and, over a long period of time, a tooth that tilted adversely could subsequently reach the occlusal level. If they had taken only two films, for instance, prior to the extraction of the second molar and at complete eruption of the third molar, they may have seen only bodily movement. Their suggestion was that the third molars were constantly altering their angulation.

OVERBITE AND FACIAL HEIGHT

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INTRODUCTION

THE term ' close bite ' is now no longer acceptable, but the concept that a deep overbite is associated with a reduced height of the face remains.

Björk (1947) in *The Face in Profile* says that overbite is inversely proportional to facial height; ' The mechanics of increased depth of bite are that the jaws close more intimately causing the face to appear somewhat compressed '. Ballard (1948) suggested that facial height does not control the overbite; that in fact a deep overbite is caused by a malrelationship which allows for overdevelopment of the incisors.

The theory of overdevelopment of incisors, where there is not an ideal Class I incisor relationship, has been re-stated both by Ballard (1966a) and by Hovell (1966), but this is not supported by cephalometric findings.

The object of this paper is to investigate the factors associated with overbite. It is realized that the soft tissues have not been studied, and that this is a static investigation of a dynamic relationship. Within these limitations the following hypotheses are examined:—

1. Where the overbite is deep the lower incisor vertical development is increased.
2. A reduced height of the face does not cause a deep overbite.
3. Only when the lower facial height is much increased does it influence the overbite.
4. The larger the inter-incisal angulation the deeper the overbite.

LITERATURE

The findings of workers in the field of overbite related to facial height are at variance with one another.

Seipel (1946), Wylie (1946), Björk (1947), Prakash and Margolis (1952), Smeets (1962), and Atherton (1965) have shown that deep overbite is associated with reduced facial height.

Björk (1947), Smeets (1962), and Atherton (1965) did not demonstrate any increase in the height of either upper or lower incisors when the overbite was increased. Seipel (1946) found no increase in upper incisor height, but did not examine lower incisor height. Prakash and Margolis (1952), did not associate lower incisor height with overbite, but showed that the vertical level of the upper incisors was related to the overbite.

Popovich (1955) found a positive correlation between overbite and the effective lower incisor height. Ballard (1966b) restated the theory that the lower labial segment shows excessive vertical development when there is a malrelationship of the incisors and pointed out that this has not been explained.

Atherton (1965) suggested that lower facial height controls the overbite and that the apparent ' kick up ' of the lower incisors is due to control of the buccal segments. He also compared complete and incomplete overbites in Class II, division 1 malocclusions and found that lower facial height is greater in the incomplete group.

Following Ballard's (1948) postulation concerning inter-incisal angulation: Fleming (1961) investigated this and showed that upper and lower incisor angulations were related to overbite; and Popovich (1955) demonstrated that inter-incisal angulation was increased with deep overbite.

MATERIAL AND METHOD

Lateral skull radiographs of 100 adult females over 17 years, when skeletal maturity has been reached (Goldstein, 1936), and up to 30 years of age were used. These were either pre-treatment records of orthodontic patients or of volunteers from the staff of the Royal Dental Hospital. Any subject who had received orthodontic appliance treatment was omitted.

All the films were taken by the same radiographer using a Watson cephalostat with a 72-in. tube–film distance, and 8·5-in. sagittal plane–film distance.

The radiographs were traced by the author in the conventional manner, using points as defined in Krogman and Sassouni (1957) (except for Incision Superius and Incision Inferius). Linear measurements were made perpendicular to the maxillary plane. This method overcomes the problem of angulation of the incisors which

Presented at the meeting held on 12 January, 1970.

influences a direct measurement. Linear measurements were taken to the nearest 0·5 mm. and angular measurements to the nearest 0·5°.

The accuracy of the tracing method was checked using a double determination of 10 radiographs.

The incisor occlusion of the subjects was assessed following Backlund's (1958) method: in the Class I group the lower incisors contacted the second part of the upper incisors; in the Class II group the lower incisors contacted the third part of the upper incisors or the palate; the Class III group was composed of occlusions where the lower incisors contacted the first part of the palatal surface of the upper incisors, as well as edge-to-edge and reversed overjet occlusions. Where the overbite was incomplete an assessment of overjet was used.

Linear Measurements (co-ordinates to the maxillary plane) (*Fig.* 1).

1. *Lower incisor height:* Gnathion to the tip of the most superior mandibular incisor.
2. *Overbite:* The vertical distance between the tip of the most superior mandibular incisor, and the tip of the most inferior maxillary incisor.
3. *Upper incisor height:* Anterior nasal spine to the tip of the most inferior maxillary incisor.
4. *Lower facial height:* Anterior nasal spine to gnathion.
5. *Upper facial height:* Anterior nasal spine to nasion.

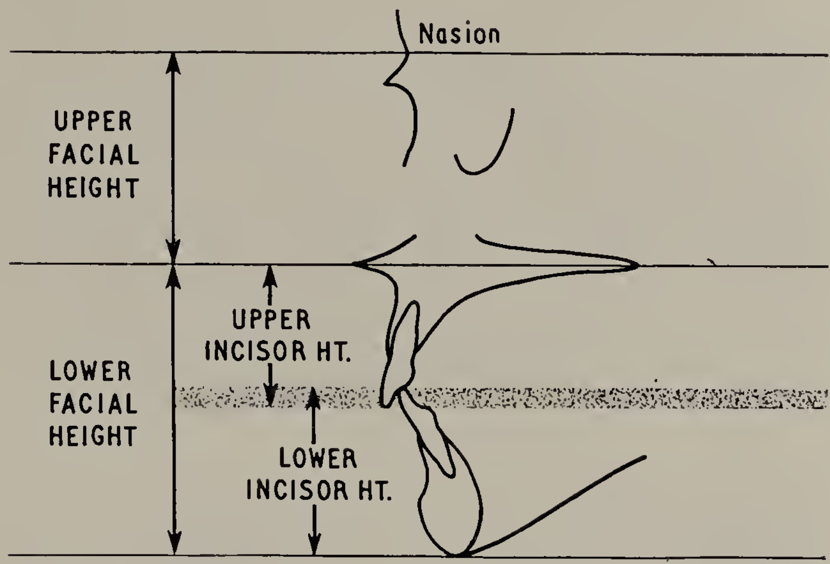

Fig. 1.—Linear measurements used, the overbite is shaded.

Angular Measurements

6. *Maxillary-mandibular-plane angle:* Anterior nasal spine—posterior nasal spine to gnathion-gonion.
7. *Lower incisor angulation:* Lower incisor long axis to mandibular plane (gnathion-gonion).

Table I.—Correlation Coefficients

	Lower Incisor Height	Overbite	Upper Incisor Height	Lower Face Height	Upper Face Height	Maxillary-mandibular-plane Angle	Lower Incisor Angle	Inter-incisal Angle	Upper Incisor Angle
Lower incisor height		0·12	0·51	0·68	0·05	0·38	0·24	0·00	0·01
Overbite	0·12		0·07	0·00	0·00	0·00	0·04	0·31	0·27
Upper incisor height	0·51	0·07		0·73	0·00	0·45	0·11	0·00	0·08
Lower face height	0·68	0·00	0·73		0·02	0·58	0·15	0·03	0·00
Upper face height	0·05	0·00	0·00	0·02		0·00	0·00	0·00	0·00
Maxillary-mandibular-plane angle	0·38	0·00	0·45	0·58	0·00		0·27	0·00	0·01
Lower incisor angle	0·24	0·04	0·11	0·15	0·00	0·27		0·24	0·04
Inter-incisal angle	0·00	0·31	0·00	0·03	0·00	0·00	0·24		0·68
Upper incisor angle	0·01	0·27	0·08	0·00	0·00	0·01	0·04	0·68	

Table II.—THE COMPARISON BETWEEN RANK ORDER SUB-GROUPS OF LOWER INCISOR HEIGHT (HIGH, AVERAGE, AND LOW)

NUMBER IN GROUP					OVERBITE	UPPER INCISOR HEIGHT	LOWER FACE HEIGHT	UPPER FACE HEIGHT	MAXILLARY-MANDIBULAR-PLANE ANGLE	LOWER INCISAL ANGLE	INTER-INCISAL ANGLE	UPPER INCISAL ANGLE
26	Lower incisor height (mm.)	High	Mean	47·27	7·42	35·58	75·44	57·15	31·15	87·00	133·79	108·58
			S.D.	* (1·89)	* (3·51)	* (2·86)	* (4·78)	(4·09)	* (5·59)	* (6·95)	(18·19)	(14·13)
49		Average	Mean	42·17	4·82 *	31·74	69·12 *	56·73	25·54 *	93·13 *	131·95	109·66
			S.D.	* (1·54)	(2·85)	* (2·89) *	* (4·04)	(3·61)	* (6·02)	(7·97)	(13·51)	(10·48)
25		Low	Mean	37·70	4·86	28·64	61·48	55·44	19·86	97·92	132·74	109·74
			S.D.	(1·03)	(1·67)	(3·22)	(4·60)	(3·01)	(7·22)	(6·11)	(9·49)	(6·15)

Millimetres (Overbite to Upper Face Height); Degrees (Maxillary-mandibular-plane Angle to Upper Incisal Angle)

'*t*' value * [significant at 1 per cent [significant at 5 per cent

Table III.—THE COMPARISON BETWEEN RANK ORDER SUB-GROUPS OF OVERBITE (DEEP, AVERAGE, AND REDUCED)

NUMBER IN GROUP					LOWER INCISOR HEIGHT	UPPER INCISOR HEIGHT	LOWER FACE HEIGHT	UPPER FACE HEIGHT	MAXILLARY-MANDIBULAR-PLANE ANGLE	LOWER INCISAL ANGLE	INTER-INCISAL ANGLE	UPPER INCISAL ANGLE
24	Overbite (mm.)	Deep	Mean	9·48	45·44	34·75	70·81	56·58	28·63	88·31	142·17	101·40
			S.D.	* (2·56)	* (3·25)	* (3·19)	(5·56)	(4·46)	* (6·42)	* (8·60)	* (19·12)	* (15·41)
50		Average	Mean	5·31 *	41·13 *	30·76 *	66·53	56·22	22·39	95·01	132·13 *	110·75 *
			S.D.	* (0·87)	(3·27)	(3·77)	* (6·96)	(2·96)	* (6·46)	(7·57)	* (10·16)	(6·97)
26		Reduced	Mean	2·21	42·12	31·71	71·52	57·04	28·90	92·44	124·77	114·19
			S.D.	(1·30)	(2·75)	(3·35)	(5·37)	(4·03)	(7·46)	(7·61)	(8·90)	(6·70)

Millimetres (Lower Incisor Height to Upper Face Height); Degrees (Maxillary-mandibular-plane Angle to Upper Incisal Angle)

'*t*' value *[significant at 1 per cent [significant at 5 per cent

8. *Inter-incisal angulation:* The internal angle between upper and lower incisor long axes.

9. *Upper incisor angulation:* Upper incisor long axis to maxillary plane (ANS-PNS).

RESULTS

Statistical analysis of the material was carried out in two ways. First, all nine measurements were correlated with one another (*Table I*). Secondly, the material was divided into groups using criteria associated with the position of incisors and height of the face, and Students ' *t* ' test was used to assess the differences between the means of the groups (*Tables II–IX*).

DISCUSSION

Correlations

The correlations are limited in as much as the occlusal classification and anteroposterior relationship of the incisors are not incorporated; but overbite shows no correlation with lower facial height (*Table I*) and is therefore not inversely proportional to the lower facial height as Björk (1947) suggests. The highest correlation with overbite is the inter-incisal angulation, which in turn is influenced mainly by the upper incisor angulation.

Upper and lower incisor heights show a high correlation with each other and with lower facial height. Upper facial height has a low correlation with all the other factors considered. The maxillary-mandibular-plane angle has a high correlation with the lower facial height and with upper incisor height.

In the interpretation of correlations the work of Solow (1966) on the geometric relationship of the data correlated is important. He describes topographical correlations when two variables share a common reference point: for example ANS and gnathion are used to determine both the maxillary-mandibular-plane angle and the lower facial height, and therefore some degree of correlation is to be expected on geometric grounds alone.

Examination of Means

Because of the inherent limitation of the correlations, it was decided to subdivide the sample into various groups according to the incisor occlusion, and also by arranging the group in the rank order of some of the variables measured. This latter method was designed to produce three sub-groups for comparison with one another. These were two groups, each of approximately 25 subjects, which represented the two extremes of the range of measurement, and a third group of 50 subjects from the middle of the range. The overbite, lower facial height, lower incisor height, maxillary-mandibular-plane angle, and inter-incisal angulation were arranged in this manner, and averages for all the factors measured were calculated for each sub-group. *Tables II–IX* show the averages found and the significant comparisons between the various groups.

In examining the averages for the various groups it was found that the upper facial height was remarkably constant. The fact that a biologically variable measurement (upper facial height) close to the field of investigation remained constant indicates that differences shown by the other measurements are not related to total facial size.

The results are now considered in relation to the original hypotheses.

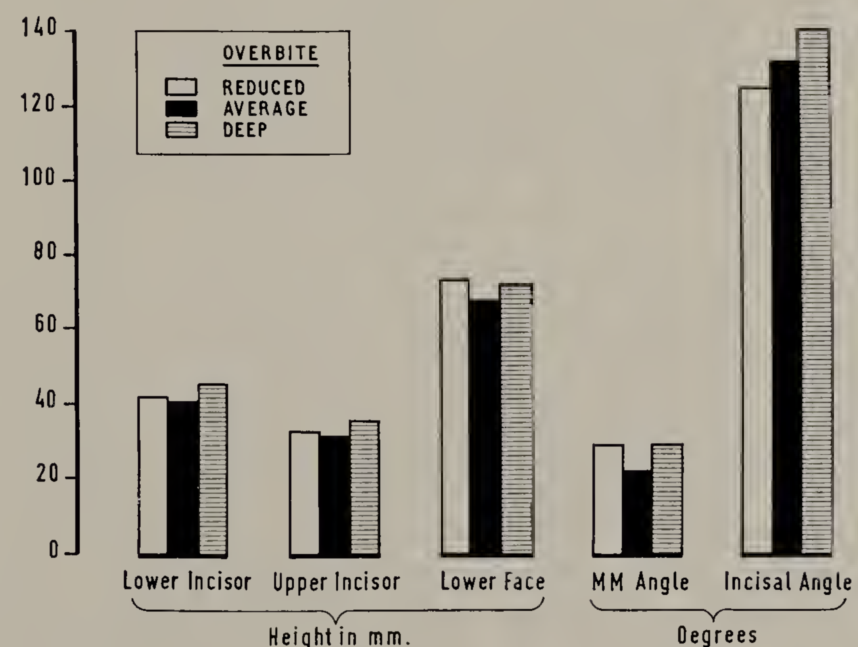

Fig. 2.—Comparison of deep, average, and reduced overbite groups.

Lower Incisor Development

The varying degrees of vertical development shown by the incisors must be influenced by individual variation in size, by the relationship of the incisors in an anteroposterior direction, and by their angulation.

To determine whether the lower incisors have an increased development associated with a deep overbite a quarter of the group with the largest lower incisor height was found to have an overbite which on average was 3 mm. greater than the rest of the group (*Table II*). In 24 subjects with the deepest overbites, the lower incisor development was increased compared with the rest of the group (*Table III; Fig.* 2). The deep overbite group showed that the upper incisor development was also increased (*Table III*). This suggests that when the upper and lower incisors are not arrested by early occlusal contact, they both develop to a greater extent.

Class II, division 1 and Class II, division 2 occlusions were compared with Class I complete overbite occlusions (*Table IV; Fig.* 3). Upper and lower incisor development is increased in the Class II, division 1 group; also the lower facial height is larger which alone may account for the

Table IV.—Class II, Division 1, and Class II, Division 2 Occlusions, compared with Class I Complete Overbite Occlusions

	Number in Group		Lower Incisor Height	Overbite	Upper Incisor Height	Lower Face Height	Upper Face Height	Maxillary-mandibular-plane Angle	Lower Incisal Angle	Inter-incisal Angle	Upper Incisal Angle
Class I (complete overbite)	40	Mean	46·85	5·55	30·66	66·00	56·30	21·41	94·61	133·46	110·76
		S.D.	* (3·40)	(1·67)	* (3·69)	* (6·05)	(3·11)	* (6·16)	(8·48)	* (9·38)	* (6·95)
Class II, Div. 1	26	Mean	45·38	5·46	33·58	73·44	57·15	30·92	91·02	124·46	113·83
		S.D.	(3·51)	(3·68) *	(3·67)	(5·98)	(4·09)	(7·53)	(8·57)	(10·83)	(7·83)
Class II, Div. 2	9	Mean	44·17	10·17	33·06	67·06	57·94	25·50	86·61	161·78	87·11
		S.D.	(1·39)	(1·11)	(1·45)	(2·13)	(0·94)	(1·67)	(2·62)	(4·16)	(4·02)
			Millimetres					Degrees			

'*t*' value *[significant at 1 per cent [significant at 5 per cent

Table V.—A Comparison of Complete and Incomplete Overbite Occlusions with the Average of the Whole Group for Reference

	Number in Group		Lower Incisor Height	Overbite	Upper Incisor Height	Lower Face Height	Upper Face Height	Maxillary-mandibular-plane Angle	Lower Incisal Angle	Inter-incisal Angle	Upper Incisal Angle
Average of group	100		42·42	5·50	31·96	68·85	56·52	25·58	92·73	132·63	109·40
Complete	64	Mean	41·94	6·34	31·14	66·76	56·49	22·86	93·11	135·55	108·93
		S.D.	(3·87)	* (2·93)	* (3·90)	* (6·22)	(3·71)	* (6·35)	* (8·71)	(14·74)	(11·45)
Incomplete	36	Mean	43·28	4·03	33·43	72·58	56·57	30·42	92·07	127·42	110·24
		S.D.	(3·73)	(2·57)	(3·35)	(5·70)	(3·53)	(6·65)	(7·34)	(10·75)	(9·09)
			Millimetres					Degrees			

'*t*' value *[significant at 1 per cent

incisor increase. The Class II, division 2 group has a lower facial height similar to the Class I complete occlusion with a relatively increased lower incisor development, but no overdevelopment of the upper incisors.

As the Class II, division 1 group contains a high proportion of incomplete overbites a comparison was made between Class I and Class II complete occlusions. Here the lower facial height is not significantly different, but both upper and lower incisor levels were increased in the Class II occlusion.

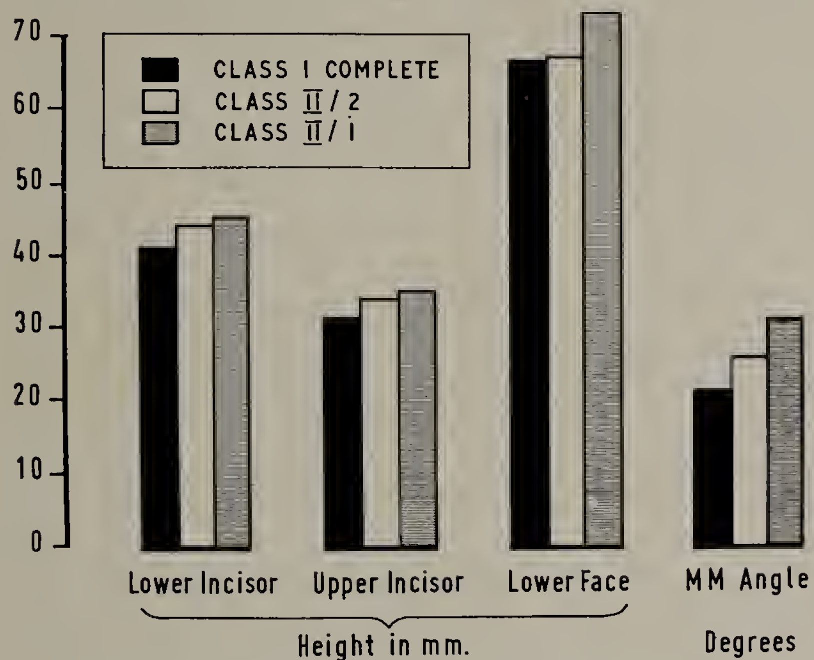

Fig. 3.—Comparison of occlusal groups.

As the lower facial heights of both the Class II complete overbite group, and the Class II, division 2 groups are similar to that of the Class I complete overbite group, the increase in overbite in these Class II occlusions can only be the result of overdevelopment of incisors and not a reduction of facial height.

Where the overbite is incomplete there is not a significant difference in the lower incisor height, but the upper incisors show an increase (*Table V*). The failure of development of the lower incisors was also found by Atherton (1965).

Reduced Facial Height

In order to assess the relationship between overbite and facial height, the material was divided according to the facial height in the rank order 27/51/22 (*Table VI*). Although the average difference for lower facial height between the extreme groups was 1·7 cm. there was no difference in depth of overbite between any of the groups. Sorting the material in rank order on depth of overbite (*Table III; Fig.* 4), it was found that the deep and the reduced overbite group had a significantly increased lower facial height. This was corroborated by the maxillary-mandibular-plane angle which was 22·4° in the average overbite group, 28·6° in the deep, and 28·9° in the reduced overbite groups. This, taken into consideration with the increased vertical development of the incisors in deep overbite cases, confirms that the depth of the overbite is related to the vertical position of the incisors and not to facial height—which is contrary to the findings of Björk (1947).

The average facial height for the different occlusions was assessed (*Table IV*). Class I complete occlusions have the smallest, with a lower facial height of 6·6 cm., compared with 7·3 cm. for Class II, division 1. The Class II, division 2 occlusions have a lower facial height similar to the Class I complete occlusions. The maxillary-mandibular-plane angle for Class I complete is 21·4° compared with 30·9° for Class II, division 1 and 25·5° for Class II, division 2, this latter figure not being significantly different from the Class I complete maxillary-mandibular-plane angle.

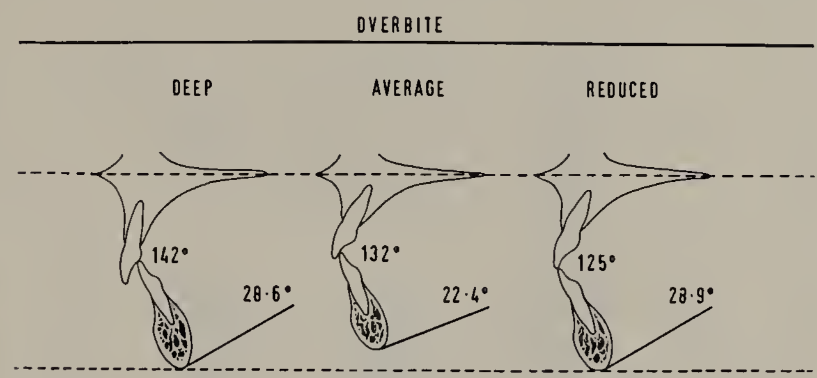

Fig. 4.—Lower facial height, maxillary-mandibular-plane angle, and inter-incisal angle in different overbite groups.

There were not enough Class III cases (6) to warrant statistical investigation and there were only 9 Class II, division 2 occlusions, but the trend for the latter was for the lower facial height to be increased compared with Class I complete occlusion. While Class II, division 2 occlusions have a lower facial height smaller than that of Class II, division 1, there is no suggestion that they have the smallest lower facial height of any occlusal group.

Increased Facial Height

As both reduced and deep overbites have been shown to be associated with an increased facial height, it was decided to compare complete and incomplete overbites, both of which may be deep or reduced.

It is assumed that an incomplete overbite may be caused by either the dento-alveolar structures reaching maximum development without completely closing the intermaxillary space, or by tongue activity. As the influence of the tongue on the vertical position of the incisors is reduced with increasing age (Tulley, 1964), it was thought that in the adult group under consideration incomplete overbites would relate principally to skeletal factors.

Lower facial height and maxillary-mandibular-plane angle are both increased in the incomplete

Table VI.—THE COMPARISON BETWEEN RANK ORDER SUB-GROUPS OF LOWER FACIAL HEIGHT (HIGH, AVERAGE, AND LOW)

NUMBER IN GROUP					LOWER INCISOR HEIGHT	OVERBITE	UPPER INCISOR HEIGHT	UPPER FACE HEIGHT	MAXILLARY-MANDIBULAR-PLANE ANGLE	LOWER INCISAL ANGLE	INTER-INCISAL ANGLE	UPPER INCISAL ANGLE
27	Lower face height (mm.)	High	Mean	77·04	46·43	5·09	35·83	57·48	32·63	88·94	128·81	109·81
			S.D.	* (3·30)	* (2·69)	(3·38)	* (2·75)	(3·53)	* (5·66)	(7·48)	(13·87)	(10·00)
51		Average	Mean	68·41 *	42·16 *	5·70	31·94 *	56·43	25·25 *	92·25 *	134·82	108·08
			S.D.	* (2·14)	* (2·53)	(3·18)	* (2·23)	(3·93)	* (5·17)	* (7·39)	(14·38)	(11·81)
22		Low	Mean	59·84	38·11	5·57	22·27	55·75	17·68	98·50	132·20	111·95
			S.D.	(3·35)	(2·35)	(2·01)	(2·57)	(2·81)	(4·92)	(8·08)	(12·48)	(8·09)

Millimetres — Degrees

'*t*' value *[significant at 1 per cent   [significant at 5 per cent

Table VII.—A COMPARISON BETWEEN CLASS I AND CLASS II INCISOR OCCLUSIONS, WITH COMPLETE AND INCOMPLETE OVERBITES

	NUMBER IN GROUP		LOWER INCISOR HEIGHT	OVERBITE	UPPER INCISOR HEIGHT	LOWER FACE HEIGHT	UPPER FACE HEIGHT	MAXILLARY-MANDIBULAR-PLANE ANGLE	LOWER INCISAL ANGLE	INTER-INCISAL ANGLE	UPPER INCISAL ANGLE
Incomplete Class I	19	Mean	41·58	3·95	32·92	70·42	55·53	28·13	94·50	127·79	109·82
		S.D.	(2·62)	* (1·76)	(3·27)	(4·88)	(3·72)	* (5·33)	(6·46)	(7·69)	(8·48)
Complete Class I	40	Mean	40·85	5·55	30·66	66·00	56·30	21·41	94·61	133·46	110·76
		S.D.	(3·40) *	(1·67) *	(3·69)	(6·05)	(3·11)	(6·16) *	(8·48)	(9·38)	(6·95)
Complete Class II	18	Mean	44·97	9·08	32·92	68·78	57·00	26·28	90·39	140·72	103·42
		S.D.	(3·52)	* (3·29)	(4·12)	* (6·11)	(4·46)	* (5·94)	(9·56)	(22·92)	(17·84)
Incomplete Class II	17	Mean	45·18	4·12	34·00	75·00	57·74	32·97	89·35	127·00	110·71
		S.D.	(3·92)	(3·30)	(3·46)	(5·70)	(2·98)	(7·18)	(7·48)	(13·63)	(9·97)

Millimetres — Degrees

'*t*' value *[significant at 1 per cent   [significant at 5 per cent

group (*Table V; Fig.* 5). This applies also to Class I and Class II incomplete overbite occlusions (*Table VII*). The development of the upper incisors is increased in all these groups, but the lower incisors do not show a significant increase in vertical height. This latter fact agrees with Atherton's (1965) findings.

What appears contradictory is that both the deep overbite group and the incomplete group have an increased lower facial height. This is due to the fact that incomplete overbites form a third of the deep overbite group. This incomplete but deep overbite group consists of Class II, division 1 occlusions with an anteroposterior skeletal discrepancy.

If the incomplete overbites in the group were the result of failure of growth potential of the lower labial segment, then the lower incisor development would be increased when compared with a similar complete occlusion. This is not so, and failure of lower incisor development has not been demonstrated in this work. A possible explanation for the findings is that the upper incisors have shown adaptation to the increased intermaxillary space when the overbite is incomplete, but that the lower incisor development has been controlled by the tongue.

Incisor Angulation

With a deep overbite the inter-incisal angulation is increased, the incisors being more nearly parallel to each other (*Table III*). In the reduced overbite group the inter-incisal angle is low, due to a proclination of both the upper and lower incisors. This is confirmed by comparing the overbite of two groups of 26 high and 25 low inter-incisal angles. These two groups show deep and reduced overbites respectively (*Table VIII*).

By arranging the material in the rank order of the maxillary-mandibular-plane angle, it was found that there was no change in the inter-incisal angulation in the sub-groups formed (*Table IX*); therefore the maxillary-mandibular-plane angle is not related to the inter-incisal angle.

CONCLUSION

It must be remembered that this is an adult sample, and the findings do not necessarily apply to a patient with a developing dentition; but it is suggested that both the upper and lower incisors have an adaptive function in maintaining an overbite by virtue of a vertical developmental potential. This is arrested by occlusal contact, or by the soft tissues, either the tongue or the lower lip. If the angulation of the incisors and the anteroposterior relationship permit, the incisors will effectively develop past one another giving an increased overbite. This is commonly seen clinically, and needs to be reduced if an ideal incisor relationship is the aim of treatment. If there is a genetic limit to the developmental potential of the lower incisors, this was not demonstrated. Perhaps this limit is only reached when there is an extremely high lower facial height, which would occur only very occasionally.

The actual depth of overbite does not seem to be related to facial height as Björk (1947) suggests; in fact the occlusions with an ideal incisor relationship and an average overbite have the smallest facial height and maxillary-mandibular-plane angle. Irrespective of occlusion, a complete overbite is associated with a smaller lower facial height than an incomplete overbite. Whether the incomplete overbite is primarily caused by the soft tissues or by the vertical relationship of the maxilla to the mandible is impossible to tell from this investigation.

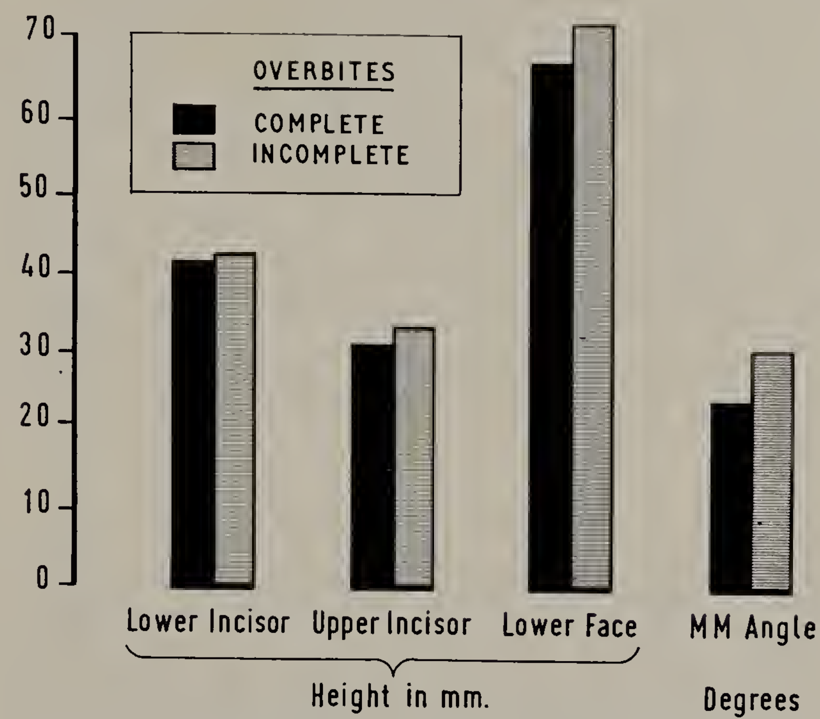

Fig. 5.—Comparison of complete and incomplete overbite occlusions.

The findings concerning the inter-incisal angulation confirm the previous literature on the subject by Ballard (1948) and Popovich (1955). It emphasizes the importance of establishing a correct inter-incisal angulation, when a deep overbite is to be reduced during treatment.

While many of the results in this paper may appear obvious, in particular the association between the lower incisors and overbite, it provides a statistical basis for commonly held clinical impression and theory.

SUMMARY

Lateral skull tracings of 100 adult females were used to assess the relationship between overbite, facial height, inter-incisal angulation, and vertical development of the incisors. A deep overbite is not related to a reduced facial height but to an increased vertical development of the incisors. When the overbite is incomplete there is an increased facial height but no overdevelopment

Table VIII.—The Comparison between Rank Order Sub-groups of Inter-incisal Angle (High, Average, and Low)

Number in Group					Lower Incisor Height	Overbite	Upper Incisor Height	Lower Face Height	Upper Face Height	Maxillary-mandibular-plane Angle	Lower Incisal Angle	Upper Incisal Angle
26	Inter-incisal angle (degrees)	High	Mean	151·21	42·58	7·73	31·75	66·56	56·54	23·79	86·73	98·79
			S.D.	* (10·91)	(3·94)	* (3·39)	(4·40)	(6·98)	(4·37)	(6·79)	* (8·47)	(12·05)
49		Average	Mean	130·42 *	41·67	4·90 *	32·00	68·81	56·04	25·38	94·33 *	110·15 *
			S.D.	* (4·64)	(3·95)	(2·14)	(3·60)	(6·17)	(3·56)	(7·01)	(6·36)	(5·86)
25		Low	Mean	117·62	43·72	4·38	32·12	71·34	57·44	27·84	95·86	118·96
			S.D.	(4·03)	(3·32)	(2·94)	(3·90)	(6·52)	(2·77)	(8·36)	(8·28)	(5·30)
					Millimetres					Degrees		

' *t* ' value *[significant at 1 per cent [significant at 5 per cent

Table IX.—The Comparison between Rank Order Sub-groups of Maxillary-mandibular-plane Angle (High, Average, and Low)

Number in Group					Lower Incisor Height	Overbite	Upper Incisor Height	Lower Face Height	Upper Face Height	Lower Incisal Angle	Upper Incisal Angle	Upper Incisal Angle
26	Maxillary-mandibular-plane angle (degrees)	High	Mean	35·08	45·83	5·48	34·79	75·00	57·25	85·35	131·02	109·10
			S.D.	* (3·86)	* (3·39)	(4·08)	* (3·07)	* (5·20)	(3·18)	* (6·32)	(16·42)	(10·96)
48		Average	Mean	25·31 *	42·28 *	5·52	32·50 *	69·30 *	56·05	94·19 *	133·36	107·32
			S.D.	* (2·68)	* (2·85)	(2·69)	* (2·84)	* (4·15)	(3·96)	(6·96)	(13·62)	(11·27)
26		Low	Mean	16·58	39·27	5·50	28·15	61·88	56·65	97·44	132·87	113·54
			S.D.	(3·06)	(3·09)	(2·36)	(3·21)	(4·95)	(3·39)	(7·25)	(12·17)	(7·92)
					Millimetres					Degrees		

' *t* ' value *[significant at 1 per cent [significant at 5 per cent

of the lower incisors. A failure of vertical development of the lower incisors associated with an increased lower facial height was not shown. Deep overbite is associated with an increased inter-incisal angle and a reduced overbite with a lower inter-incisal angle.

Acknowledgements

I wish to thank Professor Walther for his encouragement in this work and Mr. W. J. B. Houston for the statistics and much valuable criticism. I would also like to thank Miss J. A. Middleton and the Photographic Department of the Royal Dental Hospital for the illustrations.

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DISCUSSION

Dr. J. R. E. Mills congratulated Mr. Isaacson on a tremendous amount of hard work which had gone into the paper, and on the presentation which had made it very much easier for everyone to follow what was said.

It seemed Mr. Isaacson had four principal findings. He found a correlation between the inter-incisal angle and the degree of overbite. This was something which very few people had investigated statistically. From the printed paper the correlation coefficient was not a very high one. One would not expect a complete correlation but, nevertheless, it was probably statistically significant, although Mr. Isaacson did not test his correlation coefficients for statistical significance. Obviously, in some cases of Class II, division 1 malocclusion there was a deep overbite with a low inter-incisal angle, because the teeth failed to occlude and therefore over-erupted. But where they were in the same anteroposterior plane it was important. Mr. Isaacson found a correlation between the lower facial height and the completeness or otherwise of the overbite. It was surprising Mr. Isaacson had not found a correlation between lower facial height and overbite. He explained this by the fact that a third of the sample of incomplete overbites had, nevertheless, an increased overbite. Dr. Mills found this puzzling. He wondered whether this was typical or whether the sample was a little atypical.

Mr. Isaacson had found there was no correlation between overbite and lower facial height. There were nine other workers on the subject who had investigated this matter; they had all found a correlation between overbite and lower facial height.

If one had a difference of 3 or 4 millimetres the average decrease in lower facial height might be very small indeed because the decreased lower facial height was only one of several factors operating so that the average figure for this might be only a millimetre or two. Possibly for that reason a number of the investigations had not found a statistically significant correlation, but they had all found a correlation.

He found the difference between Mr. Isaacson's findings and those of other workers rather surprising. Had he thought to consider why there should be this difference? There had to be some reason for it. Could it be he was measuring from different points. He made his measurements from the maxillary plane; many of the other workers worked from the SN plane. In the two types it might be the angle between the SN plane and the maxillary plane was different. It was interesting to find out why there was this difference.

Was Mr. Isaacson sure his sample was unselected? Could he say anything on how he had picked the sample?

Another point where Mr. Isaacson showed a difference from other workers was on the question of what one might call the ' over-eruption ' of lower incisors or upper incisors and the underdevelopment of posterior teeth. Most other workers found deep overbite was associated with the underdevelopment of posterior teeth. Mr. Isaacson found it was an overdevelopment of anterior teeth. Possibly he had had a large proportion of Class II, division 1 cases, compared with other workers; it might happen, if his sample had been taken very largely of untreated malocclusions, or something like that. Other workers, on the whole, had been reputable people—and, he felt, this was a surprising finding.

The first table consisted of a very large number of correlation coefficients. There were 72 correlation coefficients. Out of the 72, 24 came to 0·00, a correlation coefficient of zero. Correlation coefficients were very complicated; one had to do a lot of subtracting, dividing, squaring and so on. The chance of everything cancelling out was minute. Mr. Isaacson presumably meant that it came to less than 0·006. Even so, he found it very surprising that these correlation coefficients gave such a small figure in so many of the cases. Could Mr. Isaacson explain this?

Mr. J. D. Muir raising what he admitted to be rather in the nature of a ' red herring ', said he could think of many excellent reasons for limiting an investigation of this sort to young adult females, but he wondered what Mr. Isaacson's reason for it had been!

Mr. J. D. Atherton congratulated Mr. Isaacson on his presentation. He was greatly relieved his paper and Mr. Isaacson's agreed on one item (namely the

increased lower face height in incomplete overbite Class II, division 1 cases), though they disagreed on almost every other.

He had been struck by one point which, he suggested, Mr. Isaacson might elaborate on. Most clinicians felt that if one had an excessively deep overbite one would not expect to find a larger maxillary-mandibular-plane (MM) angle. Admittedly, a deep overbite was caused by many factors, but not generally associated with a larger MM angle than average as Mr. Isaacson had shown (*Fig.* 4).

Regarding Mr. Isaacson's Class I group, an angle of 21° for the MM angle seemed considerably lower than the average. Perhaps one would anticipate an angle nearer the average for that particular angle in Class I malocclusion, he suggested.

Mr. R. Marx's question to Mr. Isaacson concerned the author's concept of facial height; bearing in mind that the mandible was hung below the skull, were we entitled to consider facial height with teeth in occlusion?

If we investigated people who were edentulous would we measure the facial height when the gums on the lower jaw touched the gum on the upper?

Did Mr. Isaacson think, if he were to repeat the investigation with lateral skull radiographs taken in the rest position, his findings would have been different?

Mr. Isaacson, in reply, said that he had limited the investigation to one sex for statistical reasons. He had chosen females because there were many more adult women requesting orthodontic treatment than men—consequently it was easier to collect a sufficiently large sample.

Dr. Mills's principal question had been about the results of facial height and overbite. He could not give all the reasons for differing from other workers, but he thought the main reason was that most investigators deliberately selected cases exhibiting deep or reduced overbites, and then compared these two extreme groups and found differences in facial height.

The exception to this was Björk, who had taken a random sample of Swedish conscripts and formed two groups—above and below average overbites. Björk found that the facial height was greater for the group with the overbite below average—and he argued that as the overbite increased the facial height decreased. He thought Björk was not justified in making this claim.

His was not a true random sample (it was comprised of patients, staff, and students of the Royal Dental Hospital) but he had not made reference to the overbite or facial height in the selection, and his results were obtained by comparing the middle, and ends of a normal distribution curve. There were 26 Class II, division 1 cases. He did not think that this was an abnormal number.

Regarding the problem of underdeveloped posterior teeth he had tried to measure molar heights of his group, but found that at this age the molars were so heavily restored that it was not an accurately reproducible measurement, and had had to abandon it.

He was not surprised at the low number of correlation coefficients, but asked his colleague Mr. Houston, who had assisted with the statistics, for his comments.

Mr. W. Houston said Dr. Mills had expressed surprise at the number of zero correlation coefficients. The calculations, he felt, were reliable although there was a very large number of very low correlation coefficients. Correlation coefficients, however, was notoriously difficult to interpret and it was not on these that Mr. Isaacson was basing his conclusions.

Mr. Isaacson continued and said that the Class I group, with an average MM angle of 21° which Mr. Atherton was querying consisted of 40 cases, but he emphasized that these were all complete overbite occlusions.

He did not know the answer to Mr. Marx's question, whether different results would be obtained with the mandible at rest. He could not now investigate this on the sample used. It was possible that Class II, division 1 and Class II, division 2 cases had a rest position greater than Class I cases. It would be difficult to be sure that you had got a true rest position.

SOME EXPERIMENTS WITH ORTHODONTIC SPRINGS

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THE extent of Harold Chapman's contributions to our specialty can be gauged in part by study of the transactions of our society. There are few years between 1908 and the early 1950's when his name does not figure in the formal programme, and he was also a frequent contributor to the discussions.

However, it may not be so generally known that he was responsible for four chapters in the comprehensive textbook *The Science and Practice of Dental Surgery* first published in 1914 under the editorship of Sir Norman Bennett. These chapters are on the treatment of malocclusion; aetiology having been considered in earlier chapters by Bennett himself.

While the beautifully drawn and painstakingly described fixed appliances seem dated in these days of preformed bands and Begg archwires, Chapman's general statements remain as true today as they were then. In the absence of stainless-steel wire and effective clasping systems, his preferences naturally lay in the fixed appliance field, but he describes several removable appliances, some of which would not appear grossly out of place in a modern textbook.

We feel, therefore, that he would have appreciated our paper tonight, in its attempt to investigate some of the basic principles underlying the design of the simple orthodontic springs he used then, and which we still rely on today.

In Britain, it is probable that a majority of tooth movements are carried out by 5-mm. diameter cantilever springs (finger springs). Their construction has been described by Adams (1964) and in many other standard texts. It is generally accepted by orthodontists that these springs should be activated by an amount equivalent to one-third to one-half of the mesiodistal width of the tooth to be moved, and that they require reactivation monthly.

Surprisingly, in view of their popularity, little experimental work has been carried out to investigate the performance and properties of these springs. For example, the suggestion made in several standard works (Adams, 1964; Dickson 1964; and Tulley and Campbell, 1965), and typified by the statement that ' when a coil is incorporated in a spring it operates much better if the spring is compressed against the coil ' (Walther, 1966), does not appear to be supported by any experimental evidence.

The optimum diameter of the coil, the gauge of wire used, even the benefits gained by the actual presence of the coil have yet to be examined.

The present investigation was planned as an attempt to clarify these points. The resistance to fatigue failure of various designs of spring was also examined.

REVIEW OF THE LITERATURE

McKeag (1935) discussing the action of this form of spring, advocated the use of 0·35-mm. wire. He noted that a 5-mm. deflection of the spring at a point 18 mm. from its fixed end produced a pressure of approximately 20 g.—a value said to be in keeping with the investigations of Schwartz (1932).

Wild (1950) carried out a series of experiments on differing types of springs. To simplify the taking of readings when deflecting cantilever springs by varying loadings, he used springs ten times the normal size made in 1·9-mm. wire (his ' normal ' being a spring 1 cm. long and 0·35 mm. in diameter). His work showed the desirability of incorporating a coil in the spring, but the quantitative results are of little assistance in clinical practice in view of the large springs used.

More recently, Harcourt and Munns (1967) have investigated finger springs fractured in use. They conclude that it is desirable to reduce local stresses in the spring by machine forming and also suggest that double coils may help to reduce the risk of fracture.

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Chapman Prize Essay presented at the meeting held on 9 February, 1970.

However, none of these authors have considered the ideal spring. Its essential property must be the ability to deliver the optimum force over the desired range of tooth movement (*Fig.* 1). Problems at once arise over the question of the optimum force, as the authorities are in disagreement here. The standard British textbooks are united in recommending a pressure of 20–25 g. per square centimetre of root area—a pressure directly related to the capillary blood-pressure. Tulley and Campbell (1965) go further and state that ‘ practically speaking, a pressure of 20–25 g. (1 oz.) can be applied to a single-rooted tooth with a root area of approximately 1 square centimetre ’. However, this statement is difficult to interpret in the light of information provided by Kantorowicz (1963). Average root areas given for single-rooted teeth of significance to the orthodontist are 2·045 sq. cm. for the upper central incisor, 2·665 sq. cm. for the upper canine and 2·722 sq. cm. for the lower canine.

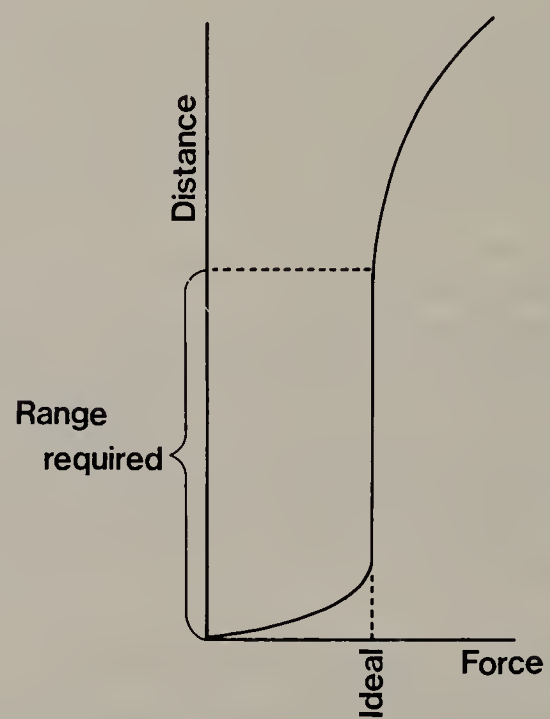

Fig. 1.—Force/distance curve for ideal orthodontic spring.

It would appear that such opinions are based on the original investigations of Schwartz (1932). However, more recent work casts doubts on some of his conclusions. Storey and Smith (1952) found that near bodily retraction of lower canine teeth could be achieved satisfactorily by forces varying from 135 g. to 300 g. They concluded that it was impossible to determine with any accuracy the optimum forces required for tooth movement. Burstone (1962) also noted similar rates of tooth movement produced by markedly differing forces. As these findings were obtained from measurement of rate of tooth movement produced by continuous forces delivered by fixed appliances, their values must be applied with caution to the intermittent forces delivered by springs carried on removable appliances. Bien (1967) reported on a series of animal investigations he had carried out and also reviewed his own earlier work. He concluded that for successful tooth movement the duration of application of the force to the tooth was of considerably greater significance than the absolute magnitude of the force.

It is evident, therefore, in the absence of any satisfactory experimental clinical study of the effect of forces applied by springs carried on removable appliances, that ‘ clinical experience ’ is still the only guide. If one-third of the width of the tooth is taken as the correct degree of activation for a spring, then the magnitude of the force will depend on which tooth is being moved. Horowitz and Hixon (1966) provide data concerning the average widths of permanent teeth. As these vary from 8·5 mm. for the upper central incisor to 5·3 mm. for the lower central incisor, it is evident that markedly different forces will be applied when one is using this simple rule-of-thumb guide to degrees of activation. The efficacy of the rule, however, is demonstrated by the fact that countless courses of orthodontic treatment have been completed satisfactorily by its use.

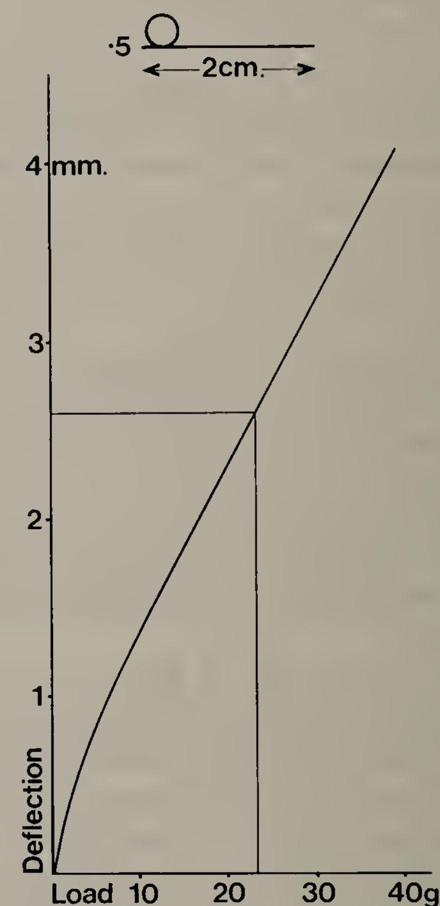

Fig. 2.—Load/deflection curve for typical orthodontic spring.

While doubts still exist concerning the maximum force that can be applied to a tooth, all observers are agreed that when the applied force falls below a certain critical value, tooth movement ceases. This clinical impression was confirmed for fixed appliances by Storey and Smith (1952), when they showed that a definite force was still being applied by their experimental springs after tooth movement had ceased.

Reference to *Fig.* 2 shows that the activation of a typical spring by one-third of the width of, say

an upper canine tooth (2·6 mm., the average width given by Horowitz and Hixon being 7·8 mm.) will produce a force of between 20 and 25 g. When the tooth has moved 1–1·5 mm., which may be taken as a reasonable distance between the typical monthly adjustment visits, little further movement will occur without

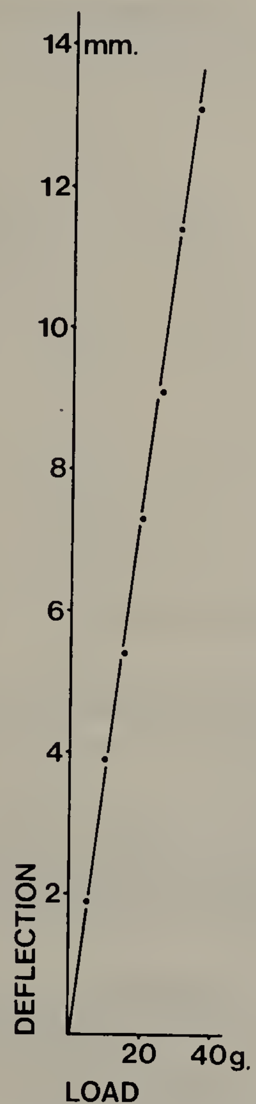

Fig. 3.—Load/deflection curve for length of expanded coil spring.

reactivation of the spring. It would seem, therefore, that this critical force is approximately 8–10 g.

The relatively rapid decline of the applied force to the critical level below which tooth movement ceases, shows how inefficient is the conventional spring.

While force applied per millimetre of activation must be the most significant measure of the efficiency of operation of a spring, other factors are relevant to the design. Simplicity of manufacture, resistance to breakage, and ease of adjustment are also of importance. The first and second of these are probably the reasons why the spring devised by Softley (1960) has not become more popular. As the active part of the mechanism is a length of fine wire (0·15-mm. diameter) coil spring running on the labial bow of the removable appliance, the rate of decline of pressure can be much less rapid than with the conventional 'finger' spring. For instance, it was found experimentally that the length of a piece of expanded coil spring (0·15-mm. diameter wound on 0·9-mm. diameter) could be reduced from 32·4 mm. to 19·3 mm. by progressive loading up to the limit of 35 g., all but 2 mm. being above the critical minimum force (*Fig.* 3).

METHODS AND RESULTS

Standard Springs

Since it was thought to be desirable to produce uniform springs for test purposes, a prototype spring-forming machine was constructed from a

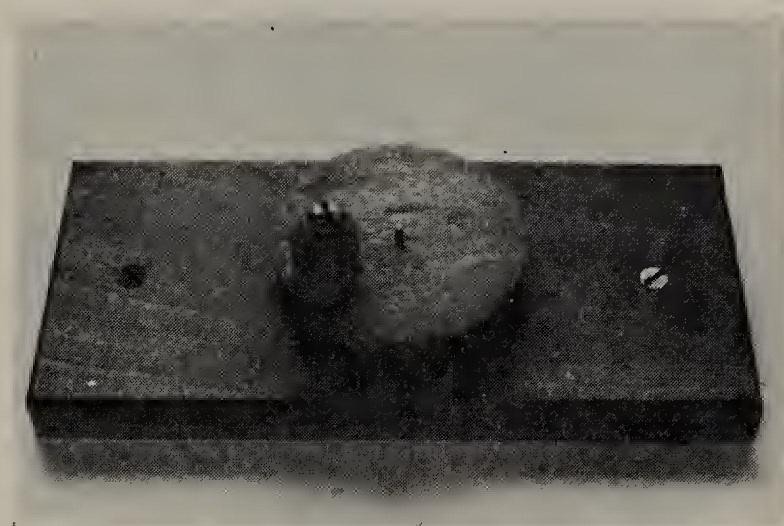

Fig. 4.—Spring-forming machine.

Fig. 5.—Completed spring.

close grained hardwood (*Fig.* 4). This was found to perform so well in practice that the original intention of reproducing it in metal was abandoned.

The shank of a straight bur was used as a spindle (diameter 2·35 mm.). Slots in the base and cylinder were cut with a fine-toothed dovetail saw to hold 0·5-mm. diameter wire. It was found that a rotation of the cylinder through about 420° produced springs with coils of approximately 2·5-mm. internal diameter (*Fig.* 5). This dimension is in reasonable accord with the statements of Dickson (1964) that the internal diameter of the coil should be about four times the diameter of the wire, and of Adams (1964) that the coil should be of 3–4-mm. diameter (internal or

external unspecified). It can be seen from careful examination of *Fig.* 5 that wood has been pared away on the left side of the spindle and in a similar area of the cylinder (*Fig.* 6). This was done to allow the lower surface of the cylinder to remain in contact with the upper surface of the block while the cylinder was being rotated,

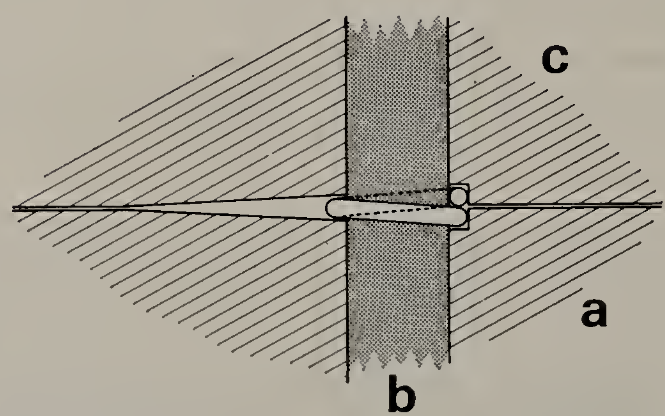

Fig. 6.—Section through spring-forming machine showing (a) base, (b) spindle, (c) cylinder. For clarity the cylinder is shown slightly raised from the base.

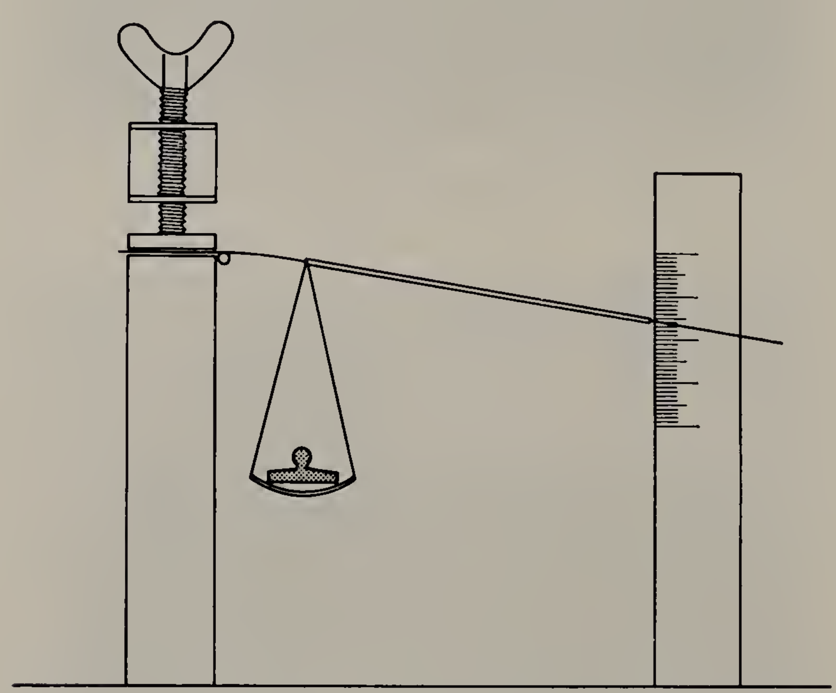

Fig. 8.—Apparatus used to measure deflections of springs.

and was found to assist in the production of uniform springs with true circular coils.

Care was taken to ensure that after the forming of the coil, the two straight limbs of the springs were in line. No attempt was made to rectify springs that had been overcoiled, these were discarded to avoid possible error.

To establish an average length for palatal canine retraction springs, 100 such springs were cut from discarded appliances and measured. A distribution curve derived from these measurements indicated an average length of 2 cm. (*Fig.* 7).

Load/Deflection Tests

1. *Conventional and Unconventional Coils*

Fifty standard springs were fabricated as described above from one coil of 0·5-mm. hard drawn stainless-steel wire (breaking strain 125·5 tons per sq. in.)*. Each spring was then clamped in an apparatus with its long axis horizontal, loaded by placing weights in a pan supported by the spring at a point 2 cm. from the clamp and the deflection produced by differing loadings measured on a vertical scale. Accuracy of measurement was

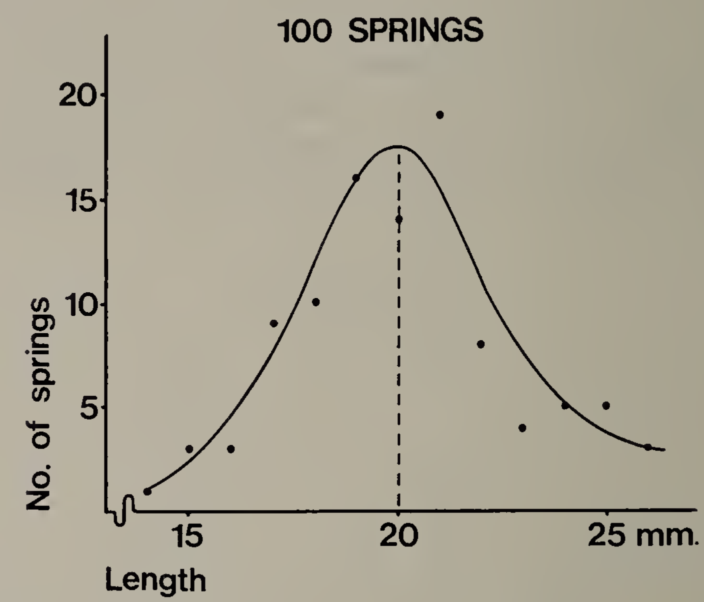

Fig. 7.—Distribution curve of spring lengths.

increased by noting deflection at a point 10 cm. from the clamp, thus magnifying the reading five times (*Fig.* 8).

The weight of the acrylic resin pan and the tubular steel sleeve, 1·19 g., was discounted as it was the same for all readings.

Table I.—Example of Typical Load/Deflection Table
(Spring No. 10)

Load (g.)	Deflection (mm.)
1	0·5
2	1·5
4	3·0
5	3·5
7	4·5
10	5·5
12	6·5
15	8·5
20	10·5
25	13·0
30	15·0
35	17·5

Each spring was progressively loaded to ‘ wind up ’ or contract the coil (i.e., the conventional design) to allow a load/deflection table to be prepared (*Table I*). Readings were taken for loadings increasing to a maximum to 35 g. This was thought to be in keeping with the generally accepted optimum pressure of 20–25 g. applied to

*K. C. Smith & Co.

a single-rooted tooth (Tulley and Campbell, 1965; White, Gardiner, and Leighton, 1967).

The deflection readings were then reduced to the actual deflection occurring 2 cm. from the clamp. Mean deflections and standard deviations were then calculated for the 50 readings for each loading.

Table II.—DETAILS OF BATCHES OF 10 SPRINGS TESTED TO DESTRUCTION

WIRE SIZE (mm.)	COIL DIAMETER (INTERNAL) (mm.)	COIL NUMBER	REMARKS
0·5	2·5	1	
0·5	2·5	1	Flexed ' wrong way round '
0·5	2·5	1	Heat treated
0·5	5·2	1	
0·6	5·2	1	
0·5	2·5	2	

Table III.—SPRINGS LOADED TO ' CONTRACT ' (CONVENTIONAL WAY) AND ' EXPAND ' COILS

LOAD (g.)	DEFLECTION			
	Contracting Coil		*Expanding Coil*	
	Mean (mm.)	Standard Deviation (mm.)	Mean (mm.)	Standard Deviation (mm.)
1	0·16	0·04	0·15	0·07
2	0·34	0·09	0·30	0·08
4	0·62	0·12	0·53	0·12
5	0·75	0·16	0·65	0·13
7	0·99	0·14	0·86	0·14
10	1·31	0·18	1·14	0·11
12	1·55	0·19	1·34	0·13
15	1·86	0·18	1·63	0·16
20	2·33	0·20	2·10	0·19
25	2·79	0·23	2·54	0·16
30	3·28	0·22	3·01	0·21
35	3·71	0·25	3·45	0·21

This *Table* provides the data for *Fig.* 9.

A further series of readings was then obtained in a similar way, the springs being loaded in the opposite direction to expand the coils. Mean deflections and standard deviations were again calculated for each loading.

The results of this and subsequent experiments will be shown graphically. The graphs and histograms are based on *Tables III–IX.*

Fig. 9 shows load/mean deflection curves for the springs with contracting and expanding coils. The curves limiting the cross-hatched areas indicate the standard deviations of the deflection readings.

Further examination of *Fig.* 9 shows that the spring with the conventional contracting coil is

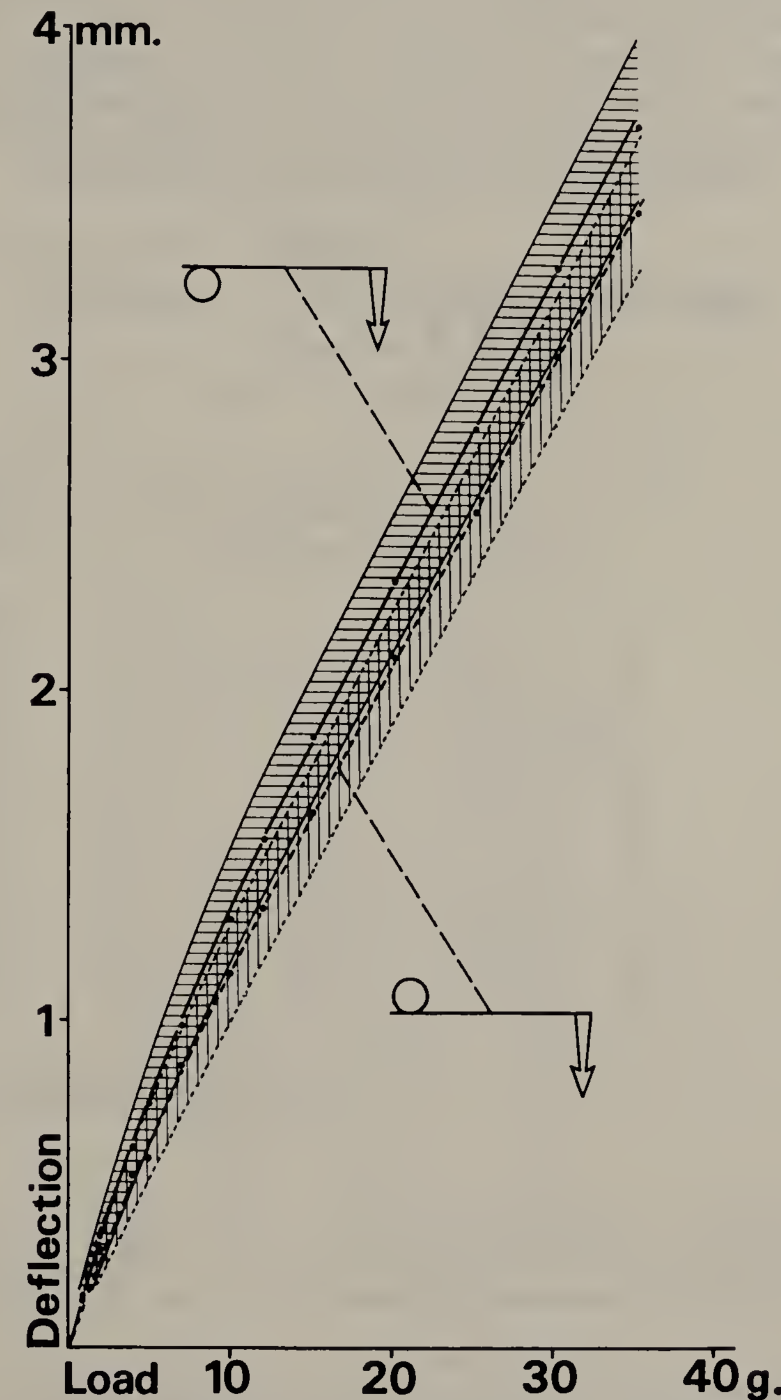

Fig. 9.—Deflection of springs with ' contracting ' and ' expanding ' coils. Standard deviations shown by cross-hatching.

Fig. 10.—Enlarged view of ' expanding ' and contracting coils at 3·5 mm. deflection. The vertical bars are the same length.

more flexible than the universally condemned opening coil spring, but that the difference is minimal. It appears that this can be explained on purely geometrical grounds and it is not the effect of any inherent property of the conventional spring. As the springs are loaded, the conventional coil tends to decrease in size and the 'wrong way round' coil to increase in size. In fact the conventionally loaded coil appears to resist further compression almost completely, most of the deformation of the wire occurring at the fixed end of the spring. Examination of *Fig.* 10 confirms this and also shows the enlargement of the coil of the other spring.

As more wire is incorporated in the enlarging coil of the unconventionally loaded spring, its effective length diminishes. This reduces the moment of the applied force and so reduces the deflection for a given load.

This hypothesis was confirmed by measurement of the internal diameters of the coils of two of the springs loaded to a deflection of approximately 3·5 mm. Direct measurement was not attempted in view of the small changes anticipated;

Table IV.—Deflections of Lengths of Straight Wire

Load (g.)	Deflection							
	2·2 cm.		2·4 cm.		2·6 cm.		3·0 cm.	
	Mean (mm.)	Standard Deviation (mm.)	Mean (mm.)	Standard Deviation (mm.)	Mean (mm.)	Standard Deviation (mm.)	Mean (mm.)	Standard Deviation (mm.)
1	0·10	—	0·12	0·04	0·19	0·03	0·21	0·08
2	0·20	—	0·26	0·07	0·34	0·05	0·39	0·08
4	0·43	0·05	0·50	0·08	0·71	0·03	0·86	0·10
5	0·51	0·03	0·63	0·07	0·82	0·04	1·09	0·10
7	0·77	0·07	0·88	0·11	1·21	0·07	1·45	0·11
10	0·90	0·07	1·16	0·11	1·51	0·06	1·98	0·12
12	1·07	0·07	1·33	0·13	1·76	0·05	2·29	0·12
15	1·31	0·07	1·68	0·13	2·13	0·06	2·88	0·12
20	1·65	0·05	2·16	0·11	2·73	0·07	3·71	0·14
25	2·00	0·07	2·62	0·12	3·30	0·08	4·55	0·10
30	2·39	0·07	3·05	0·11	3·85	0·07	5·43	0·15
35	2·73	0·07	3·56	0·14	4·42	0·14	6·25	0·28

This *Table* provides the data for *Figs.* 12 and 13.

Table V.—Deflections of Springs with Large Coils

Load (g.)	Deflection	
	Mean (mm.)	*Standard Deviation* (mm.)
1	0·21	0·07
2	0·41	0·07
4	0·86	0·06
5	0·99	0·06
7	1·39	0·07
10	1·65	0·09
12	1·92	0·08
15	2·29	0·12
20	2·87	0·10
25	3·43	0·12
30	3·97	0·11
35	4·51	0·10

This *Table* with the left hand columns of *Table III* provides the data for *Fig.* 14.

Table VI.—Deflections of Double-coil Springs

Load (g.)	Deflection	
	Mean (mm.)	*Standard Deviation* (mm.)
1	0·18	0·04
2	0·36	0·06
4	0·69	0·06
5	0·90	0·08
7	1·18	0·13
10	1·58	0·09
12	1·87	0·09
15	2·30	0·10
20	3·00	0·12
25	3·65	0·11
30	4·31	0·16
35	4·89	0·13

This *Table*, with the left hand columns of *Table III*, provides the data for *Fig.* 15.

Table VII.—Deflections of Springs made in 0·6-mm. Wire with 'Large' Coils

Load (g.)	Deflection	
	Mean (mm.)	*Standard Deviation* (mm.)
1	0·11	0·02
2	0·21	0·04
4	0·42	0·02
5	0·49	0·07
7	0·67	0·07
10	0·82	0·09
12	0·96	0·10
15	1·19	0·08
20	1·52	0·11
25	1·85	0·13
30	2·19	0·14
35	2·51	0·14

This *Table*, with the left hand columns of *Table III*, provides the data for *Fig.* 16.

measurements were taken from the images of the two springs projected onto a screen and were subsequently reduced to the actual values. The circumferences of the two coils were then calculated and subtracted from the known lengths of the springs. The effective length of the conventionally loaded spring remained at 2 cm. while the length of the other fell to 1·94 cm.

It appears, therefore, that the only effect of the coil is to increase the length of the spring within the space available in the mouth. A second series of readings was taken to confirm this.

2. *The Significance of the Coil*

Ten of the standard springs were prepared, cut, and trimmed with stones to a length of 2 cm. overall (*Fig*. 11), the measurements being made with a vernier calliper accurate to 0·05 mm. They were then carefully uncoiled, straightened out with pliers, and measured again. Their average length was 3·025 cm. (range 3·02–3·04 cm.). Incidentally, this very limited range in the lengths of the straightened springs shows the accuracy to which the machine forms them.

Load/deflection tests were next performed on 10 straight 3-cm. lengths of the 0·5-mm. diameter wire taken from the same coil as that used in experiment 1. Three-centimetre lengths were used as the apparatus shown in *Fig*. 8 was not thought to be sufficiently accurate to measure the deflection attributable to 0·025 cm. of wire. The same precautions were taken to enhance accuracy as were employed in experiment 1. The results of these tests are shown in *Fig*. 12.

As this provides the surprising information that a plain wire is deflected by a given load almost twice as far as the same length of wire formed into a conventional ‘ spring ’, the experiment was continued to allow the preparation of load/deflection tables for shorter lengths of straight wire. In this way it was possible to discover by how much the coil increased the effective length of the spring (*Fig*. 13).

Examination of *Fig*. 13 shows that a 3-cm. length of wire formed into a conventional spring is as functionally effective as a piece of straight wire approximately 2·45 cm. long. In other words the inclusion of a coil reduces its flexibility by more than half. The straight 3-cm. length of wire, were it possible to use it in the mouth, would function appreciably more effectively than the same length of wire formed with a coil into the conventional spring, because it provides a larger increase in deflection for each unit increase in load.

It becomes evident, therefore, that to improve the action of the spring within the limited confines of the mouth (i.e., an overall length of 2 cm.) more wire has to be incorporated within it.

This can be done either by increasing the size of the coil or by increasing the number of coils, keeping them to the conventional size. There was thought to be a limit to both these possibilities, namely coil size being limited by space

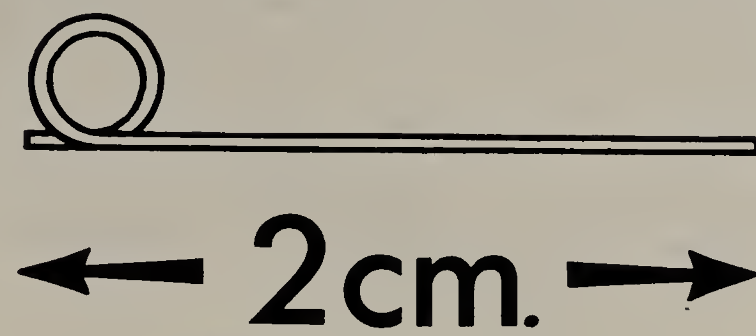

Fig. 11.—Trimmed spring.

Table VIII.—Deflections of Standard Springs following Heat Treatment

Load (g.)	Deflection: *Mean* (mm.)	Deflection: *Standard Deviation* (mm.)
1	0·15	0·05
2	0·32	0·08
4	0·58	0·07
5	0·73	0·10
7	0·93	0·11
10	1·27	0·12
12	1·49	0·15
15	1·79	0·13
20	2·33	0·18
25	2·82	0·16
30	3·29	0·19
35	3·72	0·19

Table IX.—Deflections of Hand-formed Springs

Load (g.)	Deflection: *Mean* (mm.)	Deflection: *Standard Deviation* (mm.)
1	0·14	0·05
2	0·28	0·05
4	0·61	0·04
5	0·73	0·06
7	1·03	0·08
10	1·24	0·10
12	1·45	0·11
15	1·75	0·11
20	2·23	0·11
25	2·72	0·11
30	3·18	0·15
35	3·66	0·14

within the dental arch and coil number by the thickness of the appliance.

3. *Variations in Coil Size*

As a pilot study had shown that minor variations in coil size appeared to have a limited effect on the flexibility of springs, it was decided to use springs with the largest practicable size of coil for the first stage of this experiment. This was thought to be of the order of 6 mm. external diameter. Practical experience suggested that

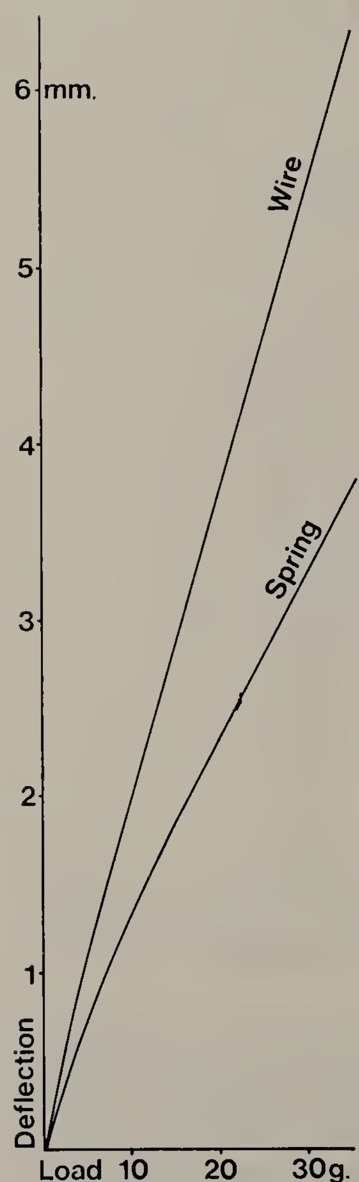

Fig. 12

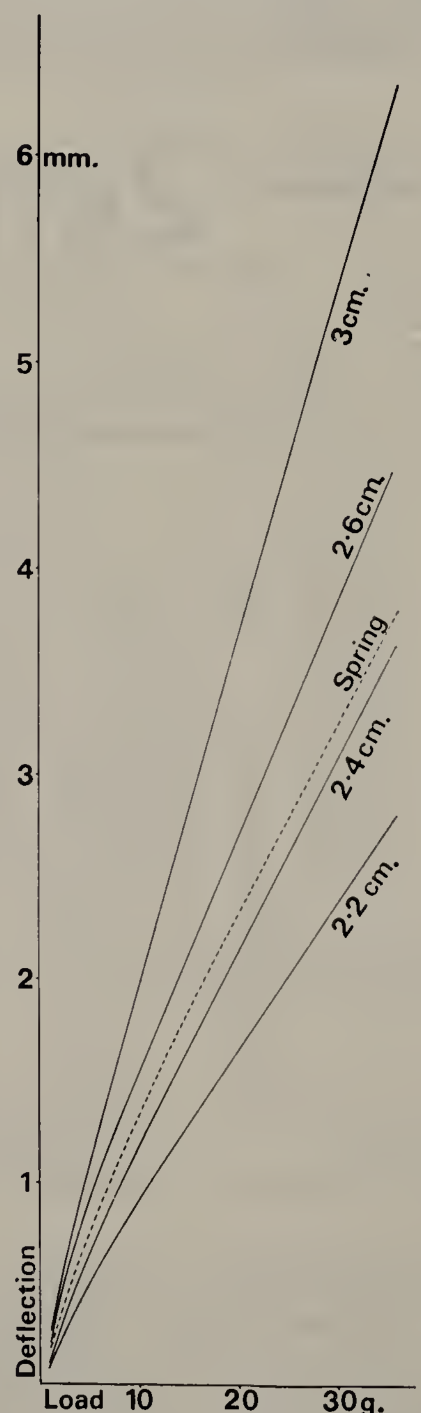

Fig. 13

Fig. 12.—Mean deflections of 20 3-cm. lengths of 0·5-mm. wire, 10 straight and the other 10 formed into conventional ' springs '.

Fig. 13.—Mean deflections of lengths of straight wire and conventional springs.

springs with coils larger than this could not often be carried on removable appliances.

A second spring-forming machine was constructed of similar design to that already described, but utilizing tube of 4-mm. external diameter as the spindle. This was found to produce uniform springs with coils of the desired diameter. Twenty such springs were prepared for the experiment. Measurement of the coils gave a mean external diameter of 6·18 mm. (range 6·1–6·25 mm.).

Each spring was then progressively loaded (contracting the coil only) as already described.

Mean deflections and standard deviations for each loading were again calculated. The graph shown in *Fig.* 14 shows the limited increase in flexibility gained by marked increase in the diameter of the coil. Ten of these springs were cut and trimmed to a length of 2 cm. (*Fig.* 11).

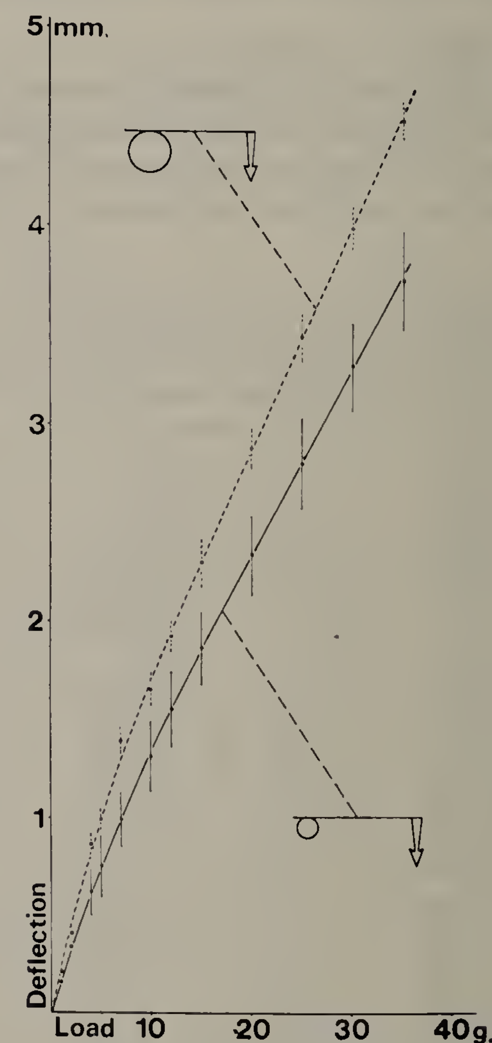

Fig. 14.—Deflections of springs with large and conventional coils. Standard deviations shown by vertical bars.

They were then straightened and measured, giving a mean length of 3·8 cm. (range 3·78–3·84 cm.).

It was not thought to be necessary to perform any further experiments on springs with coils of varying size.

4. *Double-coil Springs*

It was found that excellent double-coil springs could be formed by a rotation of the cylinder of the spring-forming machine through approximately 840° (i.e., 2⅓ turns).

Twenty such springs were produced from the same coil of wire that had been used for the previous experiments. They were then subjected to increasing loadings to contract the coils in the same way as has been already described. Readings for mean deflection and standard deviation for each loading were again calculated.

The curves shown in *Fig.* 15 demonstrate the increased flexibility resulting from the incorporation of a second coil in the spring.

Ten of the double-coil springs, following careful trimming and straightening out as described above, were found to have an average length of 4·07 cm. (range 4·05–4·09 cm.).

5. *Variation in Wire Size*

As the use of springs made in 0·6 -mm. diameter wire has been advocated for the movement

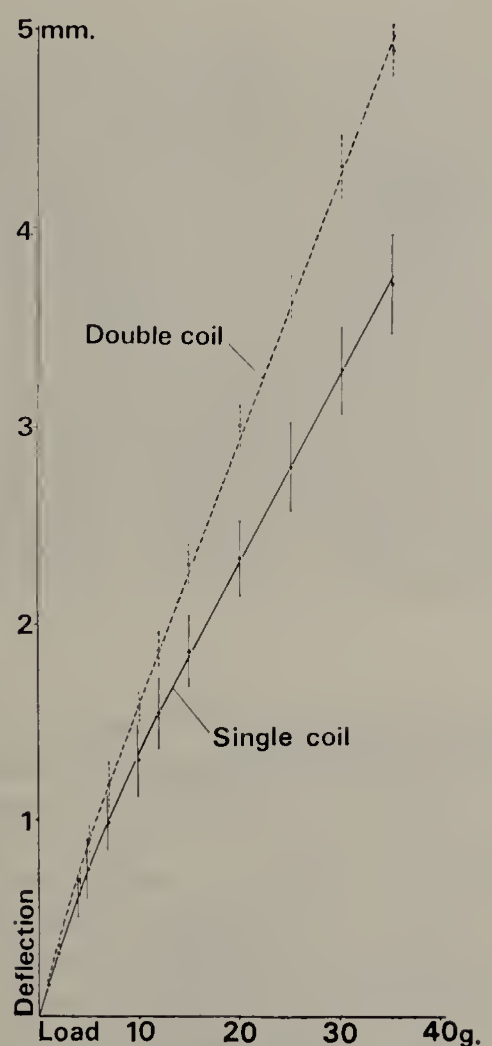

Fig. 15.—Deflections of springs with single and double coils. Standard deviations shown by vertical bars.

of certain teeth (Hooper, 1963; Dickson, 1964), it was thought to be desirable to examine the properties of springs made from this material. Twenty standard springs were formed from one coil of 0·6-mm. diameter hard drawn wire* using the machine which produced the larger coils. These had a mean external diameter of 6·17 mm. (range 6·1–6·25 mm.).

Each spring was then progressively loaded as before. Mean deflections and standard deviations were again calculated for each loading. These readings are shown graphically in *Fig.* 16 and demonstrate that the springs made from 0·6 mm. wire are, as expected, much more rigid than the conventional 0·5 mm. springs, despite the differences in coil size.

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6. *Heat-treated Springs*

Stress-relieving heat treatment of formed orthodontic wires has been advocated by several authors (Backofen and Gales, 1951; Funk, 1951; and Ingerslev, 1966).

Twenty of the springs loaded in experiment 1 were subjected to a temperature of 350° C. in a thermostatically controlled electrically heated oven for 25 minutes. The duration and temperature selected was in accordance with Ingerslev's findings. He showed that heating 18/8 stainless steel wire above 400° C. led to a marked reduction in its corrosion resistance.

Following heat treatment, the load/deflection characteristics of the springs were again examined

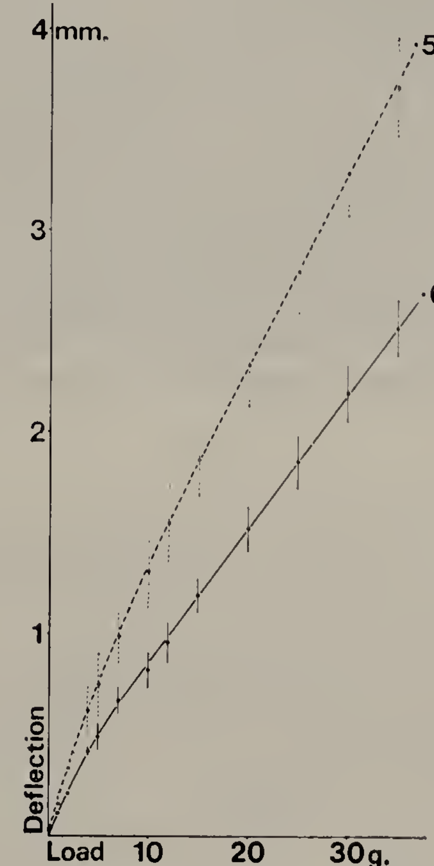

Fig. 16.—Deflections of conventional springs and 0·6-mm. springs with ' large ' coils. Standard deviations shown by vertical bars.

in the apparatus shown in *Fig.* 8. A slight but significant change in the zero point from which the original readings had been taken was noted for all but one spring. It was evident that the heat treatment had led to a slight uncoiling of the springs resulting from the relief of the internal stresses set up by the cold working of the straight wires. The 20 springs uncoiled by an average of 0·57 mm. measured at the effective end of the spring, 2 cm. from the clamp.

There were negligible differences in the deflection readings taken before and after this heat treatment, when allowance had been made for the change of zero point. (*See Tables III* and *VIII* for confirmation.)

7. *Hand-formed Springs*

Twenty springs were hand-formed with pliers, by an experienced technician, from the same coil

of wire that had been used from the previous investigations. He was given one of the machine-formed standard springs as a guide and asked to copy it as closely as possible.

Deflection readings were then taken for these springs for comparison with similar machine-formed springs; the differences were again negligible (*Tables III* and *IX*). The mean length of the hand-formed springs after straightening was 3·1 cm. (range 3·03–3·18 cm.).

however, when this fatigue limit is exceeded, cracks eventually occur between or within the crystals of the metal and lead to its failure.

It has been found in another investigation (Stephens and Bass, 1969) that the standard 2-cm. springs were remarkably resistant to fatigue failure. For instance, 15 springs survived flexing through 7·5 mm. at a rate of 1200 flexions per minute for an average of 146 minutes. It was only when the distance through which the springs

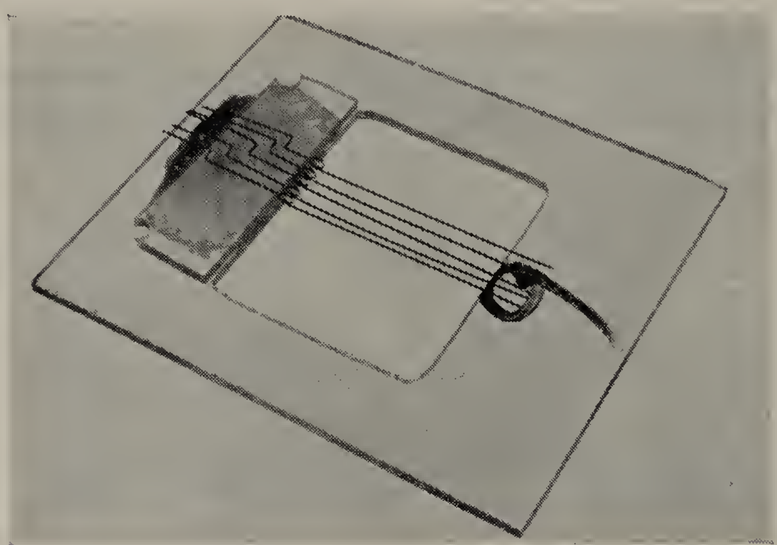

Fig. 17.—Springs mounted in frame for fatigue test.

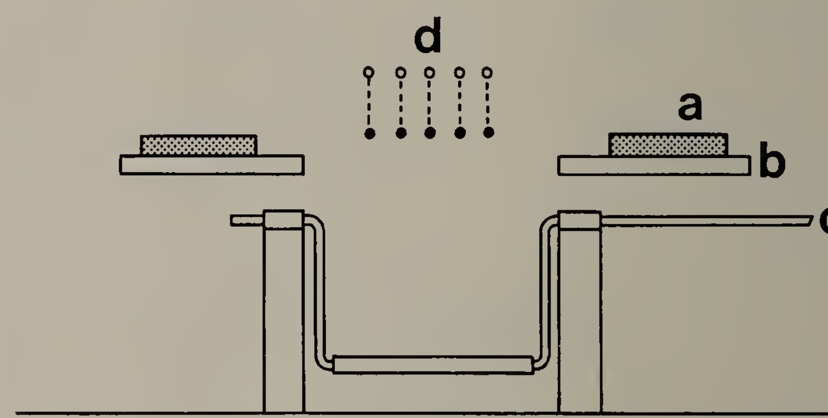

Fig. 18.—Section through flexing apparatus showing (a) ' perspex ' frame, (b) adjustable platform, (c) crank with freely rotating sleeve, and (d) springs.

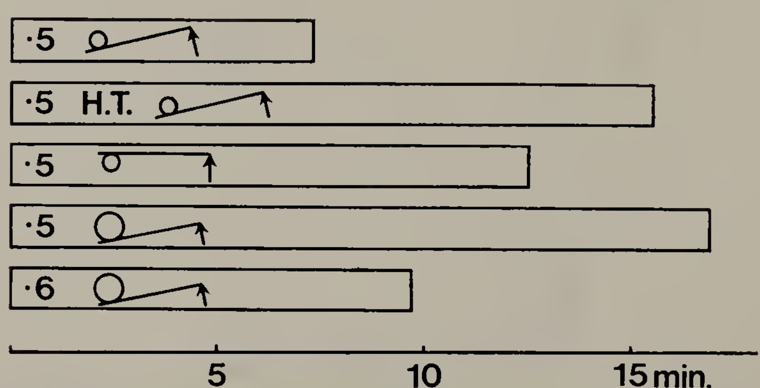

Fig. 19.—Histogram showing mean survival times for 10 of each type of spring.

were flexed was increased above 9 mm. that fracture occurred in a reasonable time.

It was decided, therefore, to compare the abilities of the various springs (*Table II*) to resist fracture by flexing them through this distance. Groups of 5 springs were mounted in ' perspex ' frames, the fixed ends being cemented into place with cold-curing acrylic resin (*Fig.* 17). The frames were bolted down on a horizontal metal platform with a rectangular hole cut in it corresponding to the holes in the frames. Below the platform in horizontal bearings ran a shaft into which was bent a crank that projected through the rectangular hole at each revolution of the shaft (*Fig.* 18). The shaft could be rotated by a dental lathe which ran at a constant speed of 1200 r.p.m. The height of the platform was adjustable relative to the shaft to allow variation in the distance through which the springs could be flexed. As already stated this was standardized at 9 mm. maximum deflection at a point on the springs 2 cm. from their fixed ends. These measurements were checked for each frame with a vernier calliper accurate to 0·05 mm., before the lathe was started to test the springs to destruction. The time at which each spring fractured was noted with a stop-watch to the nearest 5 seconds.

The histogram in *Fig.* 19 shows mean survival times for 10 of each type of single-coil spring. Failure normally occurred at the point where the wires emerged from the acrylic frames. The only

Fatigue Tests

When a metal is stressed beyond its elastic limit it becomes permanently deformed by distortion of its crystalline structure. At the same time the metal sample becomes more resistant to further deformation, whilst its capacity for further plastic change becomes reduced. With further distortion the rise in the internal stresses of the metal eventually leads to spontaneous cracking, unless low-temperature stress-relieving heat treatment is carried out to allow slight internal crystalline adjustment.

A different type of failure may occur when a metal is repeatedly stressed below its elastic limit. The stressing can take the form of impact, twisting, tension, compression, or repeated flexion. The resistance of the metal to this fatigue process is known as its endurance. Below a certain level of stress, fatigue will not occur;

exceptions to this were the standard 0·5-mm. diameter springs which were flexed the ' wrong way round ' (i.e., to expand their coils). These 10 springs all fractured at some point in the coil. One of the frames that carried these springs is shown in *Fig.* 20.

The double-coil springs lasted far longer than any other, 3 still surviving on termination of the experiment after 6 hours of flexing. This represents some 432,000 flexions. Survival times of these 10 individual springs is shown in *Fig.* 21, and compared with the mean survival times of 10 standard single-coil springs. Of the double-coil springs that did fail, 4 fractured at some point in the coil and the other 3 at the point of emergence of the wire from the frame.

The difference in mean survival time between the standard springs and similar springs heat treated and springs flexed the ' wrong way ' were tested for statistical significance, using the ' *t* ' test. This showed a significant difference in survival time at the 2 per cent level between the standard and heat-treated springs and at the 1 per cent level between the standard and ' wrong way round ' springs (*Table X*).

Fig. 20.—Frame carrying 0·5-mm. springs with ' wrong way round ' coils after test.

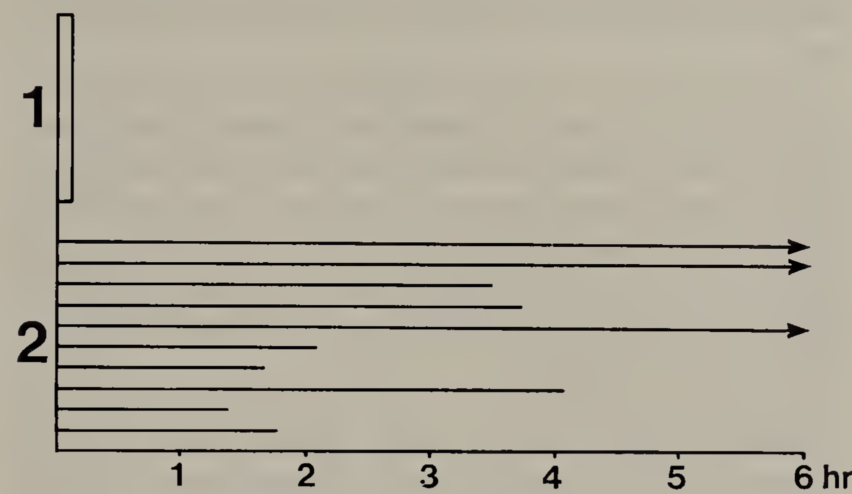

Fig. 21.—Histogram showing survival times of 10 individual 0·5-mm. double-coil springs compared with mean survival time for 10 single-coil springs.

Table X.—Mean Survival Times in Minutes and Seconds with Standard Deviations for Batches of 10 Springs

Type of Spring	Mean	Standard Deviation	Difference
Standard 0·5	7–18	3–37	
Standard 0·5 heat-treated	15–30	8–55	8–12*
Standard 0·5 flexed ' wrong way '	12–28	2–26	5–10†
Large coil 0·5	16–55	10–23	
Large coil 0·6	9–39	4–30	

This *Table* provides the data for *Fig.* 19.
*denotes significance $P<0{\cdot}02$.
†denotes significance $P<0{\cdot}01$.

DISCUSSION

The series of load/deflection tests suggests that the emphasis previously placed on the coils of orthodontic springs is somewhat mistaken. When the results of the fatigue tests are also considered it appears that the spring condemned in the literature does have some advantages over the conventional one, in that it is appreciably more resistant to these stresses (*Fig.* 19).

The load/deflection tests performed on springs made in 0·6-mm. wire (*Fig.* 16) confirm the clinical impression of the stiffness of these springs. It must be remembered, too, that these springs had large coils more than 6 mm. in diameter. The clinical implication of this is that springs made in 0·6-mm. wire should have coils as large as is practicable and that the usual rule of activation of one-third to one-half of the width of the tooth should be applied with caution.

Experiment 6 shows that stress-relieving heat treatment has no effect on the flexibility of the springs. Ingerslev (1966) found that typical fixed appliance archwires behaved in a similar way and concluded that low-temperature heat treatment

had no effect on the modulus of elasticity of the wire.

The loading of hand-formed springs (*Table IX*) was undertaken to check that the standard machine-formed springs were comparable with them. Examination of this table and the left-hand columns of *Table III* confirms this. The slight differences in length between the two types of spring and the appreciably greater differences in the lengths of the hand-formed springs (range 1·5 mm. compared with 0·2 mm. for the machine-formed springs) are evidently insignificant.

The results of the fatigue tests confirm the superiority of the double-coil spring and also suggest that heat treatment will improve the quality of the standard one-coil spring. It may be that the relief of stress in the wire forming the coil reduces the load concentration at the point of emergence of the spring from the frame, thereby delaying the failure.

It is interesting to note that the range of survival times within each group was lowest for the springs which were flexed the ‘ wrong way ’. These were the only single-coil springs which fractured in the coil, the point of failure being very variable (*Fig*. 20). It would appear that this point is determined by the chance presence and position of non-metallic inclusions in the wire (Harcourt and Munns, 1967).

When the maximal stress is localized to a limited area, as occurred with all the other single-coil springs flexed in the conventional direction (these all failed in the frame edge), the survival time depends on the presence and distribution of inclusions at this point. This could account for the much greater range of survival times observed.

SUMMARY AND CONCLUSIONS

A simple spring-forming machine has been described.

With its aid 110 ‘ finger ’ springs of varying design were produced. These were subjected to progressive loading to permit the preparation of a load/deflection table for each. Fifty of the standard springs were also loaded in the unconventional direction and a further 20 were examined following heat treatment. Twenty hand-formed springs were examined in a similar way.

Batches of 10 of each type of spring were stressed by repeated flexion to compare their endurance.

As a result of these experiments it may be concluded that the incorporation of a coil in the conventional spring serves only to lengthen it within the space available in the mouth. The flexibility of the wire in the coil is reduced when the coil is formed, thus alterations in the diameter of the coil have a limited effect on the flexibility of the spring as a whole.

The generally accepted suggestion that springs work better if the coil is compressed in operation has been shown to be incorrect.

The addition of a second loop to the coil improved the flexibility of the spring and markedly increased its resistance to fatigue.

Low-temperature heat treatment had no effect on the flexibility of the standard springs, but increased their resistance to fatigue.

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DISCUSSION

Dr. Waters, opening the discussion, said that the authors had deservedly had the meeting's appreciation for the paper which they had presented. He considered it an honour to have been asked to open the discussion. On hearing that he had been asked to do this, he had been allowed, very kindly, by the authors to read the draft of their paper. He had hoped to ' make some capital ' out of the arrangement by striking on some major blunder or cause for dissension, but, somewhat regretfully, he had to report he had found none. What followed, therefore, were a few minor cavils and some observations.

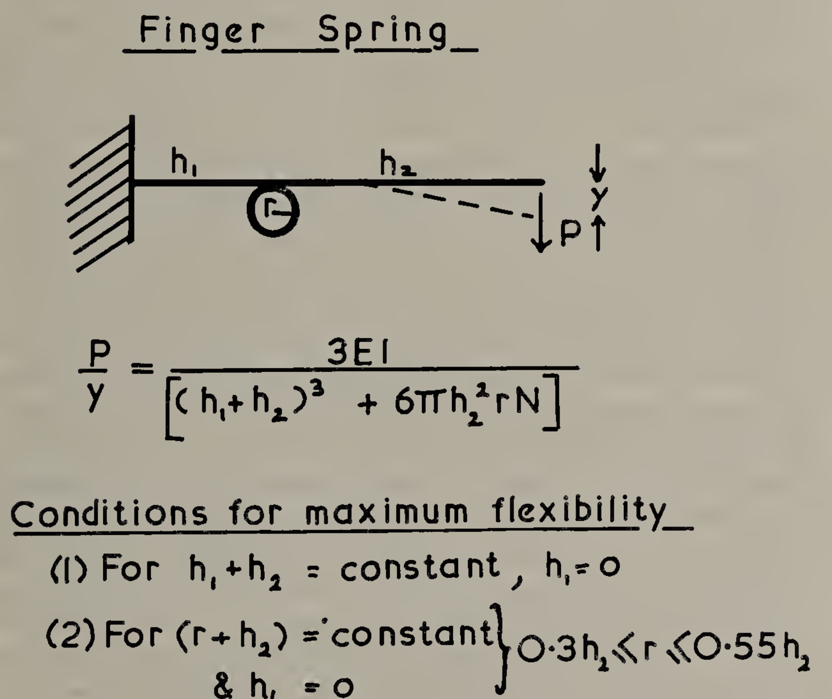

Fig. A

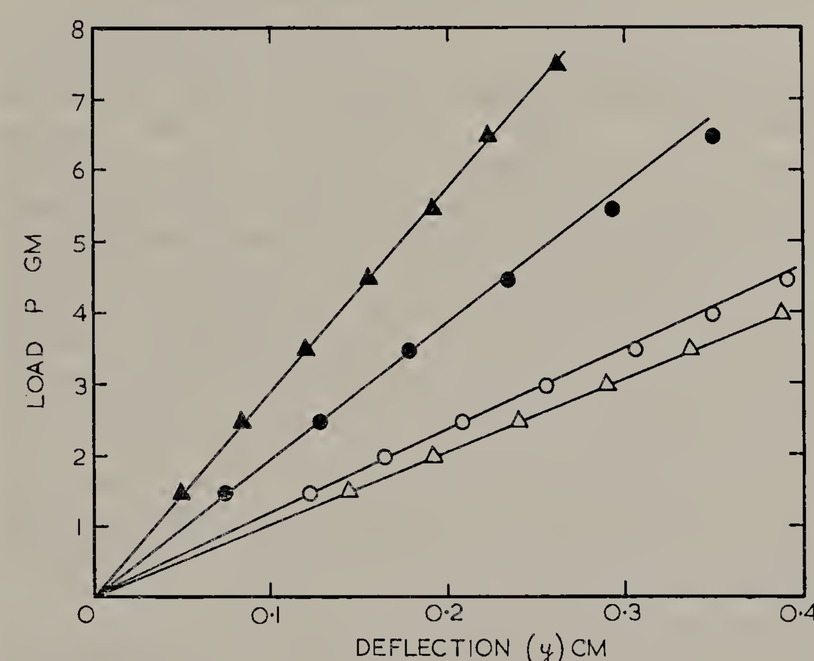

Fig. B

The first was that it was possible to analyse the mechanics of a relatively simple appliance, like a finger-spring, and so be in a position to determine theoretically some of the factors which as the authors had noted, had not received attention in the past; for example, the optimum size of the coil, the effect of wire gauge, and so on.

In showing the slide (*Fig.* A), he warned members not to be ' put off by the hieroglyphics '. The theoretical expression shown was the relationship between the applied load and the deflection for a finger-spring of the dimensions given in the diagram above it. Two things were apparent: first, the load should be directly proportional to the deformation produced; secondly, the expression itself contained some of the information to the questions posed by the authors. Finally, it also confirmed some of their own findings. For example, the authors had found one of their standard springs with a single coil to have a flexibility—in other words, a load/unit deflection—of 94·4 g. per cm. whereas calculation from the formula gave a value of 90·1 g. per cm. On changing the wire diameter from 0·5 mm. to 0·6 mm. the authors had found an increase in stiffness of 1·47, whereas the theoretical increase in stiffness came out at 1·38. The expression also showed what would happen if the dimensions remained absolutely constant and one merely changed the wire diameter—in which case, on changing from 0·6 mm. to 0·5 mm. for example, the stiffness would increase in the fourth power of the diameters; i.e., $\frac{(0{\cdot}6)^4}{(0{\cdot}5)}$ which came out at approximately 2 : 1. In the paper the dimensions had been slightly changed also.

On the question of the optimum flexibility of an appliance, two such criteria which might be derived were shown at the bottom of the slide. Thus, if the total overall length of the appliance was kept constant —the fixing arm plus lever arm of actuating arm (h_2)— for a given coil size the anchoring arm (h_1) should be as short as possible. Secondly, if h_1 was zero, the maximum flexibility was obtained with the radius $r = 0{\cdot}42\ h_2$. In point of fact, the flexibility did not show much variation between 0·3 and 0·55 h_2, but this was beyond the size of the coil which could be used in any case.

One point which caused him some uneasiness was the curvature the authors found in nearly all their load-deflection curves near the origin, because theoretically the load should be directly proportional to the deflection.

This had been borne out in his own experiments. The load-deflection characteristics of the four model appliances shown were linear. The figures on the slide showed the calculated stiffness figures in parenthesis and the experimental values for each appliance. This was in a case where dimensions had been measured on each individual spring. One could see the agreement was very reasonable in all cases.

Returning to the curvature experienced by the authors in their load-deflection experiments, it was possible that it might be due to the use of a lever arm which, although it had the advantage of simplicity and was suitable for comparative results, had the drawback of giving a variable magnification of the deflection of the appliance arm.

Another point, which might be somewhat academic, was the question of cold-working or work-hardening and its effect on the flexibility; in other words, the load-deflection characteristics. 18/8 stainless steel cold-worked very readily and, in the process, the yield stress was increased. The flexibility of an appliance was dependent, from the theoretical analysis, on three factors: the geometry of the wire, the wire gauge, and the so-called ' Young's modulus '. The Young's modulus was a parameter which was hardly affected

at all by cold-working, so that the authors' precautions to reject overcoiled springs, although perhaps justifiable on other grounds (for example, susceptibility to fracture), had, he felt, been unnecessary.

This led him to the authors' figure showing that the flexibility of a 3-cm. length of wire, formed into a conventional finger-spring, was as functionally effective as a straight wire approximately 2·45 cm. long. The point which had been made was that the cold-working of the wire to produce the coil had reduced the flexibility by more than half. He suggested that, since cold-working did not change the modulus, it was the change in the geometry of the wire which caused a reduction in the flexibility. The advantage of the coil was that it enabled one to have a more flexible appliance for the same overall length.

He was pleased to note that a neat device had been used to produce the coil or coils in the springs, because this allowed him to make ' a totally irrelevant observation ' about the spring-back of the wire on release. It was possible to calculate the percentage elastic deformation a given wire would withstand before deforming permanently, from the radius of the mandrel, the wire diameter, and the radius of the coil on release. This was just as important a physical characteristic of a wire as its modulus, but it was seldom quoted. If one type of wire was to be compared with another, this was a figure of merit which could not be ignored.

In conclusion, he once more offered his congratulations to the authors for the paper they had presented, and expressed the hope that they would continue to interest themselves in the rationale of the use of appliances in the future.

Mr. Stephens thanked Dr. Waters for opening the discussion—a task which had involved him in a considerable amount of time, calculation, and re-plotting of some of their graphical readings. ' Had we known of his interest, and expertise, in the subject of springs at the time, I think it unlikely I would be standing here tonight! ' Dr. Waters was shortly to publish a paper of his own on the subject, he added.

Taking the points raised by Dr. Waters in order—first, he was very relieved to see there was a close correlation in the flexibilities, both theoretically derived by Dr. Waters and practically derived by Mr. Bass and himself.

On the question of optimum coil size, if one accepted their practical maximum of 6-mm. internal diameter, then using Dr. Waters formulae, this was still well below the optimum for flexibility, which in their case would have been over 7 mm. This indicated the importance of keeping coils as large as possible within the space available.

One then came to the more ' thorny ' problem of non-linearity on the load-deflection curves. There had been a certain amount of collusion between Dr. Waters and the authors on this subject. They had re-plotted the readings they had obtained and, as would be seen, the upper pair of traces were the ones which had been submitted for the Essay and the lower ones were the repeated readings using a travelling microscope to assess deflection. Here a further graph was shown. In each pair the upper trace represented the conventional and the lower represented the unconventional operation of the springs (*Fig.* B.) There was no doubt but that it was the method which had produced the non-linearity.

It was interesting to note that if one re-plotted Wild's figures, in which he used an optical method for determining flexibility then he too appeared to have this non-linearity near the origin. In Wild's case it was masked by the fact that he had excluded the weight of the pan—5·95 g.—which was quite considerable. It was round about the 5 g. level that both methods produced the most marked curvature. This did not detract from the value of comparative conclusions. The two modes of spring loading, by each method, had the same relationship to each other. If anything, with the travelling microscope the differences between the ' coiling ' and ' uncoiling ' modes were even less marked.

On the subject of cold-working and elastic modulus—this had been sheer ignorance on the author's part at the time. The point Dr. Waters had made was that the elastic modulus (Young's modulus) depended on inter-atomic forces and did not change with crystalline deformation. There was a certain amount of dissension in the literature as to whether after heat treatment, subsequent to cold-working, there was a change in the elastic modulus. Ingerslev maintained there was none, but Backofen and Gale's work seemed to show a slight change. In their own case they had been ' playing safe ' in disregarding any coils which had been over-worked. Finally the ingenious method described by Dr. Waters to assess percentage elastic deformation. This was an important factor in determining the modulus of resilience—the ability of a wire to store energy, when stressed. The method seemed to have a most useful application in the rapid assessment of wire clinically, both for comparison and for further investigation.

He asked if Dr. Waters could tell him whether this method could be applied to ' U ' loops in archwires where one was not forming a complete circle.

Dr. Waters replied that the short answer was ' yes ', provided one had an arc or circle and could measure its radius. One had to know the radius of the mandrel and the radius of the wire, and the radius of the arc of the relaxed wire afterwards.

The President asked a question on the direction of coiling wire springs. Had the authors found it made any difference to the length of time that the wire would sustain a load? In other words, irrespective of the direction of coiling, could the spring be left for, say, 2 months, and when tested again at the end of that time, be found to be faithfully keeping the same resilience?

Mr. Stephens replied that this was something which had occurred to them fairly early on in dealing with springs clinically, when they appeared to have no activity in them when the appliance was removed from the mouth at a routine visit.

They had constructed a suitable, heat-controlled cupboard in which a series of springs had been kept, stressed both the conventional and unconventional ways and they were maintained in a saturated water vapour condition for a period of something over a month. During that time they had changed neither in shape nor flexibility. These had been stressed the normal clinical amount (just over 4 mm.).

Dr. Waters, regarding the difference in fatigue life of the single and double coils said that, as he remembered it, the double coils lasted much longer, but had not the deflection been the same in both cases?

Mr. Stephens agreed that this was so.

Dr. Waters suggested they might have found the fatigue life would have been the same if they had flexed them to the same stress rather than to the same deformation.

Mr. Stephens agreed this was possible. Obviously, he added, fatigue depended to a large extent on the stresses one was putting into the wire. What was interesting was that if one examined the results again one would find the 0·6-mm. springs which were less flexible and therefore had been more highly stressed than the conventional specimens made in 0·5-mm. wire in fact outlived the latter. In the double coils, however, this conclusion was open to some doubt.

Dr. Waters asked whether the authors had bent both the 0·6- and the 0·5-mm. wires around the same mandrel, in forming the coil.

Mr. Stephens said that this was not so. The 0·6 mm. had been made with the larger size coil.

Dr. Waters pointed out that in that case the degree of cold-working of the 0·6-mm. wires might have been considerably less than that of the 0·5-mm. wires which could be the explanation for the longer fatigue life of the former.

Mr. Stephens replied that this was so. It seemed it might be desirable clinically to use a 0·6 mm. with a large coil, rather than using conventional 0·5 mm. with a standard size coil.

Mr. T. Smith asked if the work had led the authors to assume that the wire in the coil least likely to break was a double circle, unconventionally wound?

Mr. Stephens replied that for any given deflection this was so, but for a given load they were not able to say from the figures which they had. It would now be useful to continue the fatigue tests, but to stress the specimens to the same load rather than to the same deflection and then consider the results.

Professor B. C. Leighton congratulated the authors on the paper and their findings. He wished to raise a point which he felt had been rather ' glossed over '—the question of adjusting the springs once they were made.

The authors had convinced their audience that it did not really matter whether one coiled the springs the right way—the accepted way—or the unconventional way. But when it came to adjusting those springs, he had the impression there was a much higher probability of deforming the spring when it was wound in the unconventional way. Had the authors done any work on this? Could they say whether the liability to breakage afterwards was greater in these springs?

Mr. Stephens asked whether Professor Leighton meant deforming in the sense of deformation as they were adjusting them.

Professor Leighton agreed with this.

Mr. Stephens replied that they had not but this point was covered in the work by Harcourt and Munns, who had advocated adjustment should be made outside the coil; the coil should be left as it was—the wire had already been sufficiently distorted.

The added advantage was that one did not tend to damage the coil further with pliers, where it had been work-hardened.

Harcourt and Munns' work showed that failure seemed to start with surface defects which were either inclusions or might be caused by abrasion—by the use of pliers for example,

Professor Leighton pointed out that many members of the profession adjusted the coil itself; this was probably the cause of breakage.

Mr. Stephens agreed that this could be expected to result in a much higher risk of breakage.

Mr. Crabb, regarding the matter of activating the spring other than at the coil, asked if Mr. Stephens would activate the wire at the same place each time. He asked if this were done over a period of six adjustments in order to get the canine right back. There would be quite a bit of work hardening, he suggested.

Mr. Stephens replied that it was a matter of chance—if one work hardened on exactly the same place on each of the six visits. At least one knew one had more of a chance of hitting a non-work-hardened place than if one went to the coil. This was an academic point.

One very rarely saw the finger-spring break outside the coil. It was either within the coil, as Harcourt and Munns had found, or at the insertion of the cantilever coil assembly into the acrylic.

Mr. J. Muir thanked the authors for an excellent and stimulating paper.

He asked Mr. Stephens to sum up what he considered to be the design points of an ideal finger-spring.

Mr. Stephens said that the paper asked considerably more questions than it answered. It seemed that they should re-examine both the type of wire which was used, from the point of view of diameter, and he felt there was something to be said for going over to 0·6-mm. diameter wire and incorporating a large coil rather than the more customary 0·5 mm. Also, he felt, that coils should be left alone and the spring activated elsewhere as described earlier. Apart from that, what needed further investigation was that the springs did fail in practice. Considering the deflections they were using, clinically, then from the point of view of fatigue, it was very unlikely a patient, ' even if they sit and rattle their appliance like a machine gun ', would fatigue the appliance during a normal length course of treatment. There was no doubt the springs did break and occasionally mysteriously broke outside the acrylic; in other words, where the finger-spring emerged from under the acrylic, before it contacted the tooth.

It might well be that the spring was being stressed by the forces of occlusion between the acrylic and the plate and the free end of the arm where it rested on the tooth. This seemed to be a different type of fracture, which had not received any attention.

Apart from that, he could not add very much more, he said.

Professor W. J. Tulley congratulated the speakers. He had seen some of the hard work which had gone into the paper.

First, he asked if he was right in thinking that in Chapman's original pictures there had been two coil springs.

Secondly, had the authors compared coil springs fabricated on their machine with those fabricated in the conventional way?

Thirdly, he suggested hundreds of students would be ' pleased that they have been right for many years '.

Mr. Stephens said the answer to Professor Tulley's first question was that Harold Chapman's appliance had had two coil springs. The historical aspect was ' fascinating '. It was very difficult to find where the convention of the coil ' unwinding in action ' had come from. It was also difficult to find where, in the proceedings, 0·5 mm. had been adopted as the suitable size wire for making the coils. It was also interesting to note the complete lack of double coil springs in the comparatively recent literature until Harcourt and Munns had advocated this.

Hand-formed springs had been compared and this had borne out the work of Funk, who had pointed out how the hand-forming of springs led to considerable variations in their properties. He felt they could not have drawn the comparisons they had without using machine-formed springs.

Mr. J. C. Stephenson enquired of the authors whether they had investigated the effect of the rapidity of forming the actual coil on the behaviour of the coil afterwards.

Mr. Stephens replied that they had not done this, but the thought had already occurred to them.

It seemed that forming a coil more slowly would possibly lead to less residual stress having formed in the wires.

Dr. Waters added that he did not think that the change in the rate of forming which could be brought about in practice would alter the amount of residual stress significantly.

Mr. Stephens said it seemed unlikely that flow would have anything to do with it, since it did not take place at this sort of temperature. Nevertheless, it might be a good idea to confirm it, he added.

Mr. D. G. Gould congratulated the authors on their paper.

He pointed out that if one looked at manufactured appliances which incorporated springs, one almost invariably found they worked to compress the coils. He did not know why this was so.

The fracture of orthodontic springs, he suggested, might not be due necessarily to fatigue but perhaps to damage to the wire during the production of the appliance. He had in mind appliances in the mouth, not experimental appliances. There was a strong possibility a lot of the fractures were due to damage from the rotating instruments used in preparation of the appliance.

Mr. Stephens replied that he had no information as to how the convention built up in the operation of the coil in the so-called ' conventional ' way.

Regarding damage, he said that small ' nicks ' in the stainless steel, or any other material operating in this mode, resulted in considerable stress concentration. This built up fatigue stresses very rapidly indeed and resulted in their more rapid destruction. This also had been mentioned by Harcourt and Munns.

The President said that, on the question of fatigue, he had experienced a problem with the fracture of 0·7-mm. diameter molar cribs. This had been taken with a wire manufacturer in Sheffield who had made the suggestion of using a smaller diameter wire—0·65 mm. A short clinical trial had been carried out, using the 0·65-mm. diameter wire on one side and 0·7 mm. on the other; there had been less breakage in the 0·65-mm. cribs. This though was not a spring and the fatigue might well have been brought about or contributed to by occlusal stress. But had the authors found the thinner wires had been more resistant to fatigue than the larger wires?

Mr. Stephens replied that the reverse was true in their case. The thinner wire, stressed to a given distance, had been less resistant to fatigue.

From the point of view of fatigue, as opposed to work hardening, in cribs, he thought the 0·65 mm. would be more vulnerable and found the President's comments surprising. He would not have expected them to last longer; perhaps they had been deforming 'elastically' rather than 'plastically' as 0·7 mm. might be doing.

The President added that, being thinner, they were clear of the occlusion and not subjected to such great occlusal stress.

Mr. Stephens said that one often observed a polished facet due to forces of occlusion on the crib ' flyover '.

Mr. Crabb drew attention to a slide put on the screen by Mr. Bass which showed the average root areas of certain teeth. That of the upper canine had been put at 2·4 sq. cm. Since a force of 25 g. per sq. cm. was considered to be the optimum pressure applied then in the case of the canine the pressure should be about 60 g. This was a high force and rarely used. Twenty-five g. per sq. cm. seemed an obsolete term. The active force that best moved a certain tooth seemed more suitable.

Mr. Stephens replied that what they did in practice was not, obviously, what they claimed to do in theory. There was no doubt they were not applying on canines anything like 25 g. per sq. cm. even if some teeth were being moved before completion of their root development.

Even so, at a guess, he thought it was almost impossible, with the usual 0·5-mm. springs, without activating them about a centimetre, to get them to apply the sort of force to a canine equivalent to 25 g. per sq. cm.

Mr. Crabb asked how the root area had been measured.

Mr. Stephens replied that this was not work by the authors. It had been done in Edinburgh. It was quoted in Kantorowicz's book.

Professor W. J. Tulley suggested that it was the root area of the face of the tooth which was moving.

Mr. Stephens replied that this would be so only if one accepted the concept of Jarabak and Fizzell, who talked in terms of projected root area—and also if one still agreed with the tension/pressure hypothesis.

Regarding tooth movement, there was a good deal to be said for at least considering the theory that the tooth did not move through the bone, but tended to take its socket with it. Baumrind in 1969 expressed considerable doubt in the pressure/tension hypothesis, he added. The answer was, surely, that they did not know.

RAPID MAXILLARY EXPANSION AS AN INTEGRAL PART OF ORTHODONTIC TREATMENT

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Over a long period in the earlier part of this century it was insisted, principally under the influence of Edward Angle, that it was possible to accommodate all teeth by simple expansion of the dental arch. However, it has been shown many times that in a very high proportion of cases relapse is inevitable. This has led to the almost complete abandonment of expansion with the substitution of extraction therapy. The recognition that the size of the apical base was the limiting factor led to a renewed interest in the possibility of increasing its size by mechanical means. The technique had long been available, the first case being described by Angell (1860). His concept of utilizing a screw to apply very great pressures to the maxilla via the teeth and forcing its disjunction along the midpalatal suture is still followed.

HISTORICAL REVIEW

In a survey of the literature it is interesting to note the criticisms by M'Quillen, the reviewer quoted at the beginning of the article by Angell (1860). These criticisms have been repeated many times since. He said that 'such a result appears exceedingly doubtful'. Even admitting its possibility, he thought that 'the irregularity of the teeth is a trifling affair compared with the separation of the maxilla'.

However, Goddard (1893) described a case in which explanations were offered for the observation and the discussion following the paper showed that the procedure was probably being widely used.

Towards the end of the last century clinicians had begun to realize that rapid expansion was influencing the nasal cavity as well as the vault of the mouth. Monson (1898) appreciated the value of this and considered that the enlargement of the nasal cavity was instrumental in promoting the free passage of air.

With the rise of the Angle School in the United States the technique was gradually forgotten. In Europe work continued sporadically, mainly in France and Germany.

In France the emphasis was mainly on the improvement of respiration, the orthodontic aspect playing a subsidiary role. Huet (1926) and Mesnard (1929) both considered that nasal breathing was aided.

It was with the work of Derichsweiler (1953) that interest was renewed in Germany, and subsequently in the United States and France. In Great Britain, Grossman (1963) described the use of rapid expansion in cleft palate cases and McCracken (1963) described the technique for normal cases.

Subsequently there has been a large volume of experimental and clinical work designed to show the feasibility of the method. The technique is almost always described in isolation with little reference to other malocclusions. There is no reason for this as it can be quite simply integrated into a full treatment plan in which it may play a major or much more frequently a minor role.

TECHNIQUE

The technique used is similar to that described by Derichsweiler (1953). Bands are constructed or preformed bands are selected for the first permanent molars. It has been found simpler to omit banding the first premolars as this seems to add very little to stability and has the disadvantage of requiring more time in construction. It was also found that an appliance with 4 bands was frequently difficult to insert, often due to 4 different paths of insertion.

In the selection of an expansion screw it is always best to select a self-locking variety as this avoids the danger of the screw coming apart if

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Presented at the meeting held on 12 January, 1970.

overactivated by the patient. At each quarter turn the screw should expand 0·2 mm. The correct expansion can then be calculated working on the assumption that there is a relapse to 50 per cent of the original expansion.

This technique is only one of a number of different techniques which are available. The most recently introduced, the Hyrax screw, is more hygienic in concept, being welded directly to the bands via strong wire. It is not, however, a new idea and basically resembles the first appliance made by Angell. The cap splint offers, perhaps the most certain and secure way of attachment. However, the construction requires a technician with a high degree of skill, which is not always available, and furthermore involves considerable laboratory time.

Whatever method is chosen, it is important that the screw is placed so that it opens by turning from before backwards, as it is virtually impossible to insert the key from the ‘ throat side ’ and pull forwards.

When the acrylic is finally added it can be carried up behind the incisors but this is not necessary and expansion can be achieved up to the incisors even when the acrylic forms a simple saddle between the molar and premolar regions.

Before the appliance is fitted into place, the parent is shown the method of turning the screw and practices this several times. After cementing the parent is shown, once more, the technique for turning the screw from before backwards. After a pause of 5 minutes to allow dissipation of the load the parent gives the screw a quarter turn under instruction. After a further lapse of 10 minutes a final quarter turn is given, again by the parent, after which he should be capable of continuing the adjustment unaided, the usual advice being to turn the screw twice per day, morning and evening, until the screw reaches its required expansion. If this is in excess of 8 mm. a new appliance should be constructed.

After the active expansion has ceased a resting period of 2 weeks is allowed in order to dissipate the accumulated load. According to Zimring and Isaacson (1965) this rises frequently above 20 lb. with an observed maximum of 34·8 lb., in one case, on the seventeenth day.

A further point which it is imperative to explain to the parent is the eventual appearance of a midline diastema and its spontaneous closure. Unless this is done there is invariably a panic and the screw ceases to be turned.

Fig. 1.—Anterior view of *Case* 1 before treatment and 9 months out of retention.

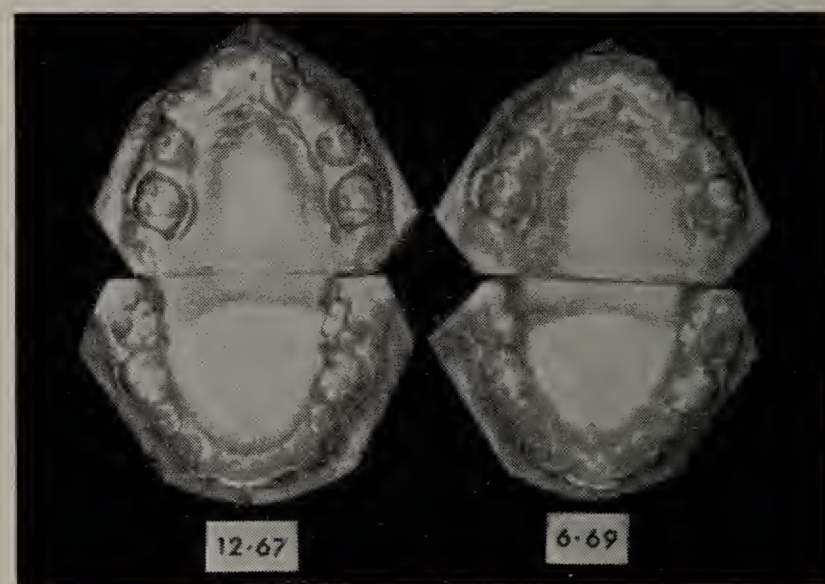

Fig. 2.—Occlusal view of *Case* 1 before treatment and 9 months out of retention.

The patient is recalled after approximately 4 weeks and a retainer is fitted.

This can be of the simple saddle type or it can be a removable appliance designed to carry out other tooth movements. Where a fixed appliance is to be used it is more convenient to fit the saddle retainer and then continue with the fixed appliance at a subsequent visit.

In any event, whatever method of retention is used the appliance must be worn full-time for a minimum period of 6 months.

To illustrate the value of expansion as an integral part of treatment three cases have been selected as examples. The first illustrates expansion combined with removable appliance therapy, the second expansion combined with fixed appliance therapy, and the third shows the stability of expansion two years out of retention, where treatment of the incisors tended to relaspe.

CASE REPORTS

Case 1 (*Figs.* 1, 2)

This was a very crowded Angle Class I case from which $\frac{74|47}{5\,|\,5}$ were extracted prior to rapid expansion. In addition $\underline{6|6}$ were moved distally, again before expansion. Complicating factors such as these are to be expected in the majority of routine cases and make the accurate interpretation of measurements very difficult. From *Table I* the contraction of the lower arch from 46·0 mm. in December, 1967, just prior to

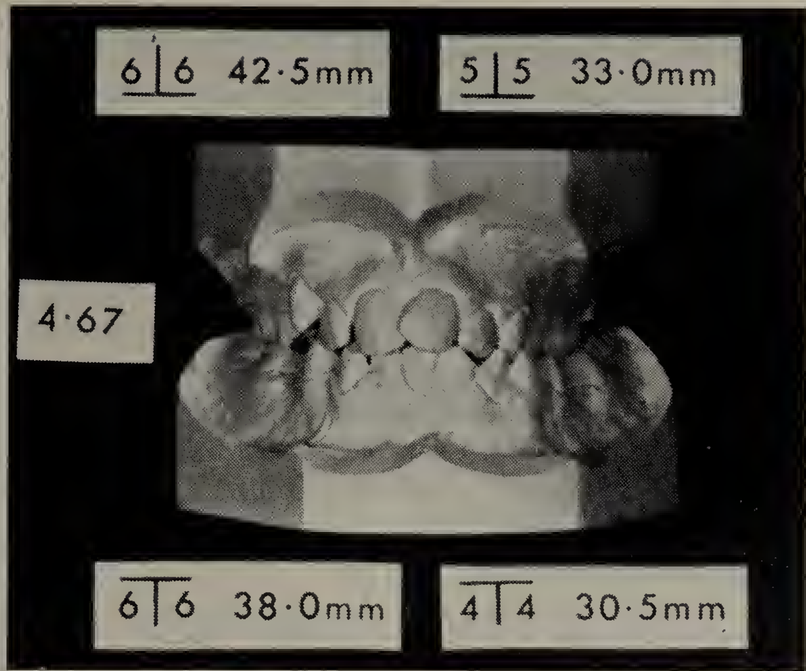

Fig. 3.—Anterior view of *Case* 2 before rapid expansion.

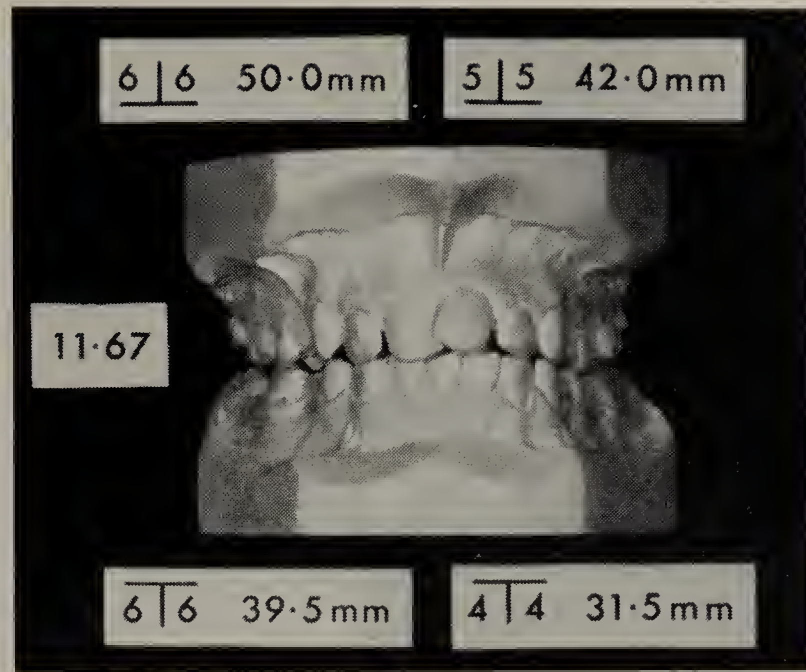

Fig. 4.—Anterior view of *Case* 2 immediately after rapid expansion.

Table I.—Measurements in *Case* 1 before Rapid Expansion, during Treatment, and 9 Months out of Retention

	Width of 6|6 (mm.)	*Width of* 6|6 (mm.)
Dec., 1967	48·0	46·0
March, 1968	58·0	45·5
March, 1969	53·0	44·0
June, 1969	52·5	44·0

Table II.—Measurements in *Case* 2 before Rapid Expansion, during Treatment, and 4 Months out of Retention

	Width of 6|6 (mm.)	*Width of* 6|6 (mm.)
April, 1967	42·5	38·0
Nov., 1967	50·0	39·5
Feb., 1969	49·0	37·5
June, 1969	48·0	37·0

Table III.—Measurements in *Case* 3 before Rapid Expansion, during Treatment, and 2 Years 2 Months out of Retention

	Width of 6|6 (mm.)	*Width of* 6|6 (mm.)
March, 1964	35·0	37·0
May, 1964	43·5	37·0
Aug., 1965	43·0	38·0
Dec., 1968	40·5	36·5

expansion to 44·0 mm. in June, 1969, at 9 months out of retention can be explained by the mesial drifting which continued in spite of extracting the lower second premolars, as shown by the increasing imbrication of the lower incisors.

As a consequence of rapid expansion the distance between the upper first molars increased from 48·0 mm to 58·0 mm. This finally fell to 52·5 mm. at 9 months out of retention. This is in excess of the usual 50 per cent relapse but can again be explained by mesial drift of the molars.

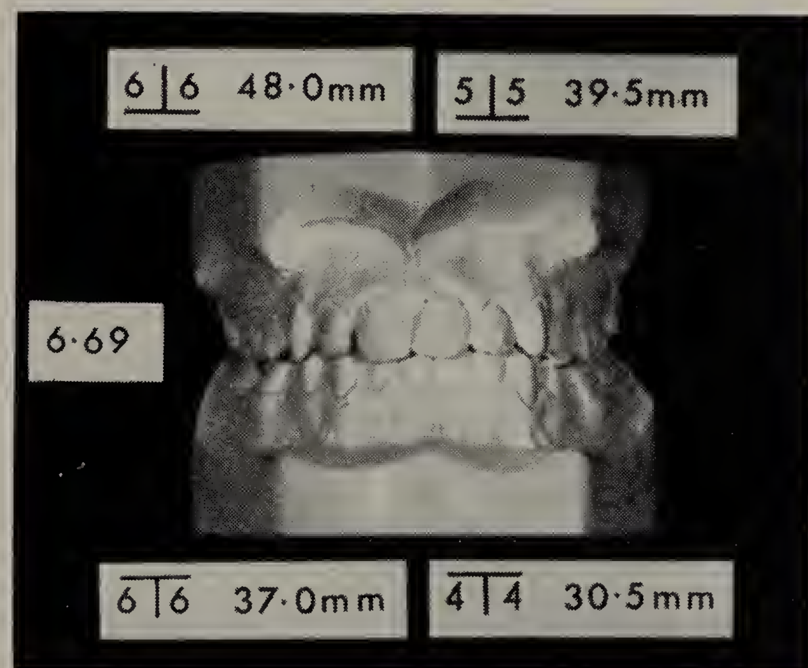

Fig. 5.—Anterior view of *Case* 2, 4 months out of retention.

Following the expansion a removable appliance was fitted to procline |2 and later a sectional arch to correct the 3|.

Case 2 (*Figs.* 3–5)

This was also an Angle Class I with a severe cross-bite causing marked deviation of the mandible to the left. Rapid expansion was used to eliminate the cross-bite but the malalined incisors remained and it was therefore decided to retain the expansion with a palatal arch whilst correcting the incisors with a twin-wire arch.

From *Table II* it can be seen that the expansion was initially 7·5 mm. At 4 months out of retention this had fallen to 5·5 mm. still well above the 50 per cent relapse to be expected.

Case 3 (*Fig.* 6)

This case was chosen to emphasize the long-term stability of rapid expansion. Contrary to the usual belief it is much more predictable as a tooth movement than correction of incisors.

The maximum expansion was 8·5 mm. rising from 35·0 mm. between the first molars to 43·5 mm. Two

years and 2 months out of retention this fell to 40·5 mm. which is 5·5 mm. out of the initial 8·5 mm.

Following the expansion a twin-wire arch was fitted to aline the incisors, retraction being achieved by

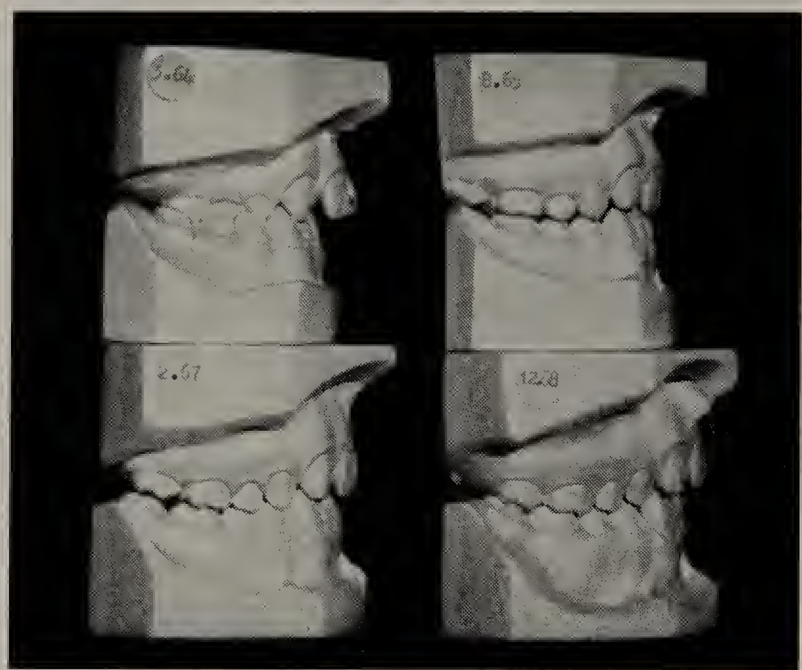

Fig. 6.—Lateral views of *Case* 3 before and during treatment, and 2 years and 2 months out of retention.

intramaxillary traction. The expansion was maintained with a palatal arch. Between March, 1964, and August, 1965 the cross-bite was eliminated and the incisors fully retracted. Four months out of retention there was little evidence of relapse, but by December, 1968, 2 years and 2 months out of retention, the incisors had worsened whereas the cross-bite had remained stable.

CONCLUSIONS

Rapid expansion is a quick efficient and safe method of treatment with excellent long-term prognosis and it can be combined with any variety of orthodontic treatment. The teeth over a long period are unstable as reference points for measurements and only approximate values can be obtained. The final clinical result is of much more relevance.

Acknowledgements

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DISCUSSION

Mr. L. A. Usiskin asked what the period of time was between the cessation of expansion and the fitting of the retainer.

He also asked if Mr. McCracken had observed whether the degree to which the occlusion was retained had anything to do with the forms of the cusps, especially of the molar teeth.

Mr. McCracken replied that he did not fit the retainer straight away. The reason for this was that he had found that if he took the appliance out immediately after expansion there was such tremendous pressure that the whole arch seemed to collapse inwards, even in a matter of 3 or 4 hours, and the retainer was a very poor fit. But if he left it for 2 weeks, all the pressures built up were dissipated and the retainer could be fitted.

Regarding the question on retention, he felt that all the experience of slow expansion had tended to show that the cusps did not retain expansion. The technique would probably never have been used at all if the cusps alone were capable of holding an expansion. This had been Angle's belief, but most people would disagree with that, he believed.

Mr. M. S. E. Gould asked if Mr. McCracken had noticed in his cases any tendency for the incisor overjet to increase when rapid expansion of the maxilla was carried out?

Mr. McCracken replied that this was a remark which had been made many times. It has been suggested as a method of treating the Class III malocclusion, but he had not obtained any permanent benefit. It seemed to be a very temporary thing. Any benefits which accrued seemed to disappear almost as quickly as the diastema.

Mr. L. J. McBride asked what reference points Mr. McCracken used for taking his measurements between the sixes.

Mr. McCracken replied that there was so much conservation of the sixes that he had difficulty in selecting any point of reference consistent from one patient to the next. He had had to take over a series of 6 models, the most reproducible point. This could vary from one to another, he added.

Mr. G. Kerr reminded Mr. McCracken that, in the literature to which he had referred, he had mentioned the question of improving nasal airway.

He had found that the ear, nose, and throat surgeon was often someone who referred cases to him, hoping that expansion would be undertaken. He had yet to find a case, he added, where the needs of the orthodontic case and the needs of the ear, nose, and throat coincided. Perhaps that was unfortunate, and it would coincide eventually.

Had Mr. McCracken worked with an ear, nose, and throat specialist in that line? Was he able to offer any evidence of improvement in nasal airway as a result of treatment?

Mr. McCracken replied that he had had this experience and had had the same difficulties as Mr. Kerr.

The strange thing about these patients was they always seemed to have very poor oral hygiene.

Very often, the patients who were referred did not have a cross-bite but normal occlusion in the buccal segments. He had never felt justified in turning a normal buccal occlusion into an abnormal one to influence nasal respiration.

Mr. E. K. Breakspear asked Mr. McCracken to comment on the type of swallow in his cases.

Mr. McCracken replied that this seemed to vary very considerably. He imagined Mr. Breakspear was wondering whether there was a low tongue position or if there were any lisps or other abnormalities. He had not noticed any constant feature in any of the cases—nothing which he could say was specifically associated with every patient or a large proportion of them.

Mr. I. Clow asked if Mr. McCracken had had many relapses in his cases. For instance had there been any return of the cross-bites in occlusion.

Mr. McCracken said he had had several, falling into specific categories. He had, to his cost, on occasions attempted to expand cases, particularly of girls of 16, 17, 18 plus. They had fallen into a very definite type—usually small, extremely well-built girls. He did not know what happened but expansion was often a complete failure.

The other category was, he found, if there was no large space when he took a postero-anterior radiograph before and after treatment. This again seemed to have a very good indication of relapse. He added that if he got a split in the bone—and this was obvious through radiographs—the rate of relapse was very low indeed, just the odd one or two.

Mr. H. Jarrah asked Mr. McCracken on what basis he felt that partial relapse occurred. Why did it not relapse fully?

Mr. McCracken replied that, due to a tilt of the teeth outwards, in 2 weeks there had to be some movement of the teeth within the alveolus and this partly accounted for it.

His own feelings did not correspond with everybody elses', he said. A most interesting lecture had been given in Edinburgh at which Mr. Stockfisch had shown a number of cases 15, 16, and 17 years out retention showing 70 per cent stability. This was something he himself had not managed to achieve. As to accounting for it, his answer would be the movement of the teeth through the bone. Perhaps he was doing more of this, he concluded.

Mr. H. K. Lewis wondered whether Mr. McCracken had taken measurements of the inter-canine width, particularly on the postero-anterior radiograph. He suspected from these cases that the anterior expansion was not as great as the expansion in the $\underline{6|6}$ area.

He asked for more details on the percentage of success achieved with the younger patients. There was a tendency to ignore that expansion of the palate was an acceptable form of treatment in this respect.

Mr. McCracken replied that he had not measured the inter-canine distance. He had used the postero-anterior radiograph in as many ways as he could, but without the metallic implant. The use of the canines might be of some value, he admitted.

Regarding the age-group, the most successful seemed to be from about 8 up to 12, 13, or 14, He had not done any expansion under the age of 5, possibly because the child would be very intolerant of it and also because he found difficulty in making suitable appliances to deciduous dentition. The cap splints would deal with this problem.

He was unable to give the percentage of success at the varying ages.

Mr. J. R. Dimock asked if Mr. McCracken had done a ' similar sort of line ' in the lower jaw, because there were obviously occasions when that might be concerned.

Mr. McCracken replied he had taken the advice of Derichsweiler, who had attempted this in every way he could think of, and was singularly unsuccessful in everything he had tried in the lower arch. The symphysis in the lower jaw just would not break. He had not attempted it himself, he added.

Mr. G. Kerr asked if a tag had been soldered to the band, to anchor it to the acrylic.

Mr. McCracken replied that this was correct.

REPORT ON THE OCCLUSIONS AND DENTITIONS OF A GROUP OF SKULLS EXCAVATED AT A CAIRN CEMETERY IN FIFE

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Little is known of the occlusions and dentitions of the earlier habitants of the British Isles and an opportunity arose to examine a group of skulls excavated at a cairn cemetery in Fife.

REVIEW OF THE LITERATURE

There are few reports of dental examinations of early skulls excavated in this country. Cooke and Rowbotham (1958) examined 301 Romano-British skulls, dated about 150 A.D. They found that 92·8 per cent had a Class I occlusion and that the incisal relationship changed, with age, to an edge-to-edge one. Smythe (1933) gave a more detailed account of 25 Anglo-Saxon skulls. She found the full range of Angle's classification of malocclusion, 2 definite Class II, division 1, 4 mild Class II, division 1, 1 Class II, division 2, and 2 pre-normal cases. Aitcheson and Johnston (1952) reported on a Viking skull in which there was ' ideal ' occlusion apart from lower incisor crowding. Moore, Lavelle, and Spence (1968) and Goose (1962) have included a wide range of material in their work on jaw osteometry but no record of the dental condition.

MATERIAL

Eighteen skulls were examined, of which only 14 were used. Of those discarded, 2 were without maxillae, 1 with an antemortem edentulous upper arch, and in 1 post-mortem loss of teeth in both arches made it impossible to classify the occlusion.

The skulls were found in a collection of long cists covered by stone cairns. In the opinion of Mr. J. Colvin Grieg, the Director of Excavation, the burials were late Iron Age to Dark Age, about 6th to 8th century A.D.

METHOD

The skulls were examined for:—

1. Dental base relationships.
2. Inter- and intra-arch relationships.
3. Caries and attrition.
4. Alveolar bone loss.

A photographic technique was devised which was based on orientations comparable with those used for cephalometric radiography. Because the skulls were so frail it was impossible to mount them accurately, and it was decided that the photographs should only be used to complement the clinical findings.

Criteria for Various Assessments

Dental Base Relationships

a. ANB angle: 0–4° was considered within average limits for the angle between nasion and Down's points A and B.

b. Skeletal pattern: Anteroposterior relationships of the incisal apical bases using the method of incisor angle correction (Ballard, 1948).

c. Frankfurt mandibular angle: Walther's (1960) criteria were used for ranking into high, moderately high, average, moderately low, and low.

Inter-arch Relationships

A modified Angle's classification was used for the relationship of the first permanent molars. The amount of attrition made assessments difficult.

Class I: Normal relationship or less than half a unit pre- or postnormal.

Class II: Half a unit or more postnormal.

Class III: Half a unit or more prenormal.

No account was taken of forward movement of lower buccal segments following antemortem loss of lower incisors.

Presented at the meeting held on 9 March, 1970.

Table I.—Main Findings from Assessments

Skull No.	Site No.	ANB Angle	Frankfurt Mandibular Angle	Skeletal Pattern	Relationship of 6/6	Incisal Relationship	Degree of Lower Labial Segment Crowding	Degree of Upper Labial Segment Crowding	Estimated Age
1	LL6	Increased	Moderately low	Mild II	II	I	Mild	Mild	17–25
2	LL11	Increased	Moderately low	Mild II	II	II/1	Mild	Spaced	17–25
3	LL1	Average	Low	Mild II	I	II inter	Not obtainable	None	25–35
4	LL16	Increased	High	Mild II	I	II/1	Moderate	Spaced	25–35
5	LL21	Increased	Moderately high	Mild II	II	II/1	Severe	Severe	17–25
6	LL7	Not obtainable	Low	Mild II	II	II inter	Moderate	Mild	17–25
7	LL9	Increased	Average	I	I	I	None	Spaced	17–25
8	LL14	Average	Moderately low	I	I	I	None	Spaced	17–25
9	LL13	Not obtainable	Moderately low	Mild II	II	II inter	Severe	Not obtainable	35–45
10	LL12	Average	Moderately low	I	II	II/1	Severe	None	17–25
11	LL4	Increased	Low	I	II	II/2	Mild	Moderate	17–25
12	LL3	Increased	Average	Mild II	N/O	II/1	Moderate	Moderate	35–45
13	LL20	Not obtainable	Low	I	II	I	Mild	Moderate	17–25
14	LL	Increased	Average	I	I	II/1	Moderate	Not obtainable	17–25

An incisor overjet of 2–4 mm. was considered average. Class I had an average overjet. Class II, division 1 overjet was more than 4 mm., Class II intermediate overjet more than 4 mm., but upper incisors appeared retroclined. Class II, division 2 central incisors with average overjet and the lateral incisors with increased overjet. Class III had an overjet of less than 2 mm.

Intra-arch Relationships

Labial and buccal segments were assessed on a ranking basis:—

a. Spaced.
b. Alined.
c. Crowded.
  i. Mild.
  ii. Moderate.
  iii. Severe.

It was not always possible to carry out assessments because of post- and antemortem loss of incisors. Where losses were unilateral, estimates were made of the space needed.

Caries and Attrition

Caries was assessed by visual inspection. Attrition was recorded on the molars only and Brothwell's tables (1965) for attrition of pre-mediaeval skulls were used to determine the approximate age at death for each individual.

Alveolar Bone Loss

This was assessed for each tooth present using Brothwell's (1965) classification of none, mild, moderate, or severe.

RESULTS

The main findings are grouped in *Table I*, and some aspects will be considered in more detail.

Table II.—Frankfurt Mandibular Angle

Angle	*No. of Skulls*
High	1
Moderately high	1
Average	3
Moderately low	5
Low	4

Table III.—Labial Segment Relationships

		No. of Skulls
Class I		4
Class II		10
Division 1	6	
Division inter	3	
Division 2	1	
Class III		0

Dental Base Relationships

Eight of the skulls were mild skeletal II and in 8 the ANB angle was increased; these characteristics were not invariably concomitant.

The Frankfurt mandibular angle showed a wide range of values, the majority having lower than average values (*Table II*). A high and a low example are shown in *Figs*. 1, 2.

Inter-arch Relationships

In 8 cases the relationship of the first permanent molars was Class II, although in 6 of these the relationship was only half a unit postnormal. No prenormal relationships were found. One upper first molar was in lingual cross-bite and in 2 other cases there was a tendency for the upper first premolars to be in a similar relationship.

The preponderance of Class II labial segment relationships was striking (*Table III*) and also the differing skull morphologies with which the malocclusions were associated (*Figs*. 3–5).

Caries

No caries was found by the method of examination used.

Fig. 1.—An example of a high Frankfurt mandibular angle

Fig. 2.—An example of a low Frankfurt mandibular angle.

Fig. 3.—Intermediate, Class II.

Fig. 4.—Class II, division 1.

Alveolar Bone Loss

Of all the teeth present in all the skulls 8 per cent had no bone loss. It was slight for 42 per cent, moderate in 21 per cent, and severe for 29 per cent of the teeth. The estimates may be

on the high side due to post-mortem loss of bone. The loss was most marked in the upper and lower anterior regions and in relationship to the first permanent molars. Most of the individuals were in their twenties at the time of death and periodontal disease seems to have been quite severe. All indications were that it was responsible for antemortem loss of teeth.

Fig. 5.—Class II, division 1.

DISCUSSION

Mr. J. Colvin Grieg, the Director of Excavation, thinks that the people buried were all members of a community who lived nearby. Unfortunately there were no datable finds from the cists, and his estimate of 600–800 A.D. is tentative.

The scarcity of information about the earlier inhabitants of these islands makes it difficult to assess how much racial intermingling has contributed to our malocclusions and how much is due to lack of vigorous mastication (Moore and others, 1968). Minor irregularities are common in primates (Mills, 1963) and in primitive isolated communities (Begg, 1954).

Evidence from pottery alone indicates that the east of Scotland was receiving migrants from about 2000 B.C. (Piggott, 1962), Although the group of skulls is small it does show that the dental base relationships, as well as the arch relationships, were incompatible with a so-called ideal occlusion.

It is difficult to estimate how much of the periodontal disease and antemortem loss of lower incisors has contributed to the malocclusions. The bimaxillary proclination shown in *Fig.* 4 may have been produced by the severe periodontal condition and as the whole of the right-hand side of the skeleton was smaller than the left, other factors may have been present. Nevertheless it is not impossible that the variations in skeletal pattern were due to racial intermingling.

Lindstrom (1946) points out that small separated groups of skulls are unlikely to be representative of their period. If the group examined had become an isolated community, once a malocclusion had been established it would be perpetuated. This could explain the preponderance of Class II malocclusions.

SUMMARY

1. A report is given of an examination of the dentitions and occlusions of a group of skulls, approximately 600–800 A.D.

2. The preponderance of Skeletal II and Class II malocclusions was unexpected.

3. No caries was found but advanced periodental disease was common.

Acknowledgements

I should like to thank Mr. Colvin Grieg for allowing me to present this report; Dr. Iain Smart for the facilities given at the Anatomy Department in Dundee for examining the skulls; Mr. Gerrish of the Medical Photography Department of the United Bristol Hospitals for his assistance; and Professor Berry and my colleagues in the Orthodontic Department at Bristol for their encouragement.

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DISCUSSION

The President thanked Miss Campbell-Wilson for her paper. He had two questions to ask her. Had she any information on the origin of the skulls in question? Had they been part of the Neolithic invasion right across Europe, or had they come more from the East? Secondly, were the skulls brachycephalic or dolichocephalic?

Mr. W. A. B. Brown asked if it was wise to define the sample as a Group of Pictish skulls when there appeared to be some doubt about the identity of the material. What guarantee was there that there was not the odd Scotsman or visiting Irishman.

Mr. G. H. Roberts expressed his pleasure in having listened to a very interesting talk. He asked the author if she had any views as to why there was so much periodontal disease in the community. One of the slides had shown a great deal of attrition and had shown more attrition on one side than on the other. On the left-hand side there had seemed to be much less. He suggested that on the side where there had been less attrition there might have been a slightly smaller condyle.

Mr. A. G. Huddart congratulated Miss Campbell-Wilson on a very interesting paper and asked her to enlarge on the age of the skulls. Would it not have been possible to have found a more accurate assessment of age by means of carbon-dating?

Mr. C. P. Adams thanked Miss Campbell-Wilson for an interesting paper. It was his recollection, from having read papers of this kind, that it was usual to try to assess whether ancient man had been better off regarding his dental development and the arrangement of the teeth than modern civilized man. Was it Miss Campbell-Wilson's impression that this was so, from the material she examined?

Mr. J. D. McEwen pointed out that in a recent talk, Mr. Colvin Grieg had commented that the bones had been found in long cists, did this fact give any help in dating the skulls? Mr. Colvin Grieg had also said that the average height of the females was 5 ft. 1½ in. and of the males 5 ft. 8½ in. Had Miss Campbell-Wilson found any differences in the skulls between males and females?

Mr. G. C. Dickson thanked Miss Campbell-Wilson for a most interesting paper. One thing which had been implied by her rather than stated was whether or not the malocclusions could have been associated with racial admixture.

Before one could make this assumption at all one had to find a few pure races that did not have malocclusions. Begg had shown this very well with the Australian aborigines who showed severe attrition, wearing away a premolar width in each quadraus. The amount of attrition in the skulls examined by Miss Campbell-Wilson was not severe by the standard of the Australian aborigines or even early Neolithic, let alone Paleolithic, man. With increased attrition there would be less overcrowding—and overcrowding had obviously been present. It would be of interest to know whether or not there was more or less overcrowding in the skulls with such attrition; he doubted whether the number of skulls would be sufficient to assess this.

Racial admixture was something which had been discussed time and again. One should leave it entirely out of the question until one had been able to show at least somewhere—and it had only to be done once—two pure races without malocclusions or with mild ones and a mixture of the two with an increased incidence of irregularity. Until that time it would be best to regard racial mixture as an unsupported hypothesis in the origin of malocclusion.

Mr. G. H. Steel asked Miss Campbell-Wilson if she had thought of carrying out any blood-group assessments from the material. He believed this was possible.

Miss Campbell-Wilson, in reply to the President's question, said she was not in archaeologist and had had to take the word of the people who had advised her. She was unable to answer the point in relation to the Neanderthal invasion.

The audience had perhaps noticed one skull which was fairly round, the other skulls being long. The people who had been excavating had considered very carefully whether the round head might have belonged to another group which had got there by mistake or whether it was an ' odd Scotsman ' who had been buried there. They had not had a good enough reason, however, for leaving him out. This was all she could say on the matter.

Mr. Brown had asked what guarantee there was that they were all the same community. She could only go on the advice she had been given. The excavator had thought they were; the same applied as to whether they were Picts or not. She realized that some might not agree with the terminology. If there was a request that the title should be changed to read ' a group of skulls found in Scotland dated about 600–800 A.D. ', she would do so—if it were thought it would be of more use to people in the future.

She was not really able to answer the question regarding periodontal disease. The people in the community were thought to be extremely poor; they certainly were not Christian. It did not appear that they suffered from any sort of vitamin deficiency. She did not know why they had severe periodontal disease and did not think anybody did know.

Regarding the lop-sided attrition, she had noticed in several that the molar teeth were not evenly worn on both sides. One could not go by the photograph in relation to the condyle; it might have been damaged in excavation.

They had not been able to do any carbon-dating, she said, because there had not been enough money.

In reply to Mr. McEwen, she said that Dr. Smart had thought some of the skulls were of men and some of women and he had been undecided about others. That was why she had not definitely divided the skulls into male and female. As to whether or not their occlusions were better than those of the present day, she felt they probably were. The group was too small to analyse statistically; it was not, however, that they had a malocclusion but it was that so many of the dental base relationships were skeletal II, which was interesting. Even in such a small group, if one had a distribution curve, one would expect to have a ' hump ' somewhere, in the range of skeletal I. In this case, which seemed so biased in one direction, she had had to think ' of some excuse '—she was sorry if they did not agree with the one she had produced.

As far as blood-grouping was concerned, this was something she had not thought of.

A STUDY OF THE BUCCAL FORCES EXERTED UPON TEETH DURING FINGER-SUCKING

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It has often been suggested that persistent sucking habits may cause a reduction in maxillary arch width and contribute to the aetiology of buccal crossbite. This suggestion is based on the hypothesis that finger-sucking is accompanied by a reduction in intra-oral pressure causing the cheeks to be pressed inwards against the teeth by atmospheric pressure. If an increase in buccal pressure does occur during sucking behaviour, it is plausible that it may cause narrowing of the maxillary arch. Such a corollary, however, has not been demonstrated by the work of Ruttle, Quigley, Crouch, and Evan (1953) and Bowden (1966) who have reported little difference in intermolar arch width between finger-suckers and control groups. Leighton (1966), on the other hand, does report a higher incidence of sucking habits amongst children with crossbites than in a control group.

The present study was undertaken to test this hypothesis by measuring pressure exerted by the cheek against the teeth in the upper first permanent molar region, whilst simultaneously recording intra-oral air pressure. Buccal pressure was recorded first whilst sitting at rest and then during sucking activity so that any change could be noted.

The subjects chosen were patients attending the Orthodontic Department at Glasgow Dental Hospital in whom a sucking habit was still active. Buccal pressure was recorded by means of a sensor of 5 mm. diameter and 1·5 mm. thickness using a technique previously described by Luffingham (1968). The sensor was positioned against the interdental space anterior to the maxillary first permanent molar and held in place by gutta-percha and Eastman 910 adhesive (*Fig.* 1). The sensor lead left the mouth in the lip line and towards the corner of the mouth so as to cause minimum interference with lip activity. The signal from this sensor provided a direct trace of buccal pressure and also drove an electronic integrator so that the total pressure exerted over a given period could be calculated. Intra-oral air pressure was recorded using an open-ended, soft vinyl tube of 2 mm. diameter attached to a Solartron transducer situated outside the mouth. The tube was positioned against the finger being sucked and

Fig. 1.—Sensor used to measure pressure exerted by the cheek against teeth.

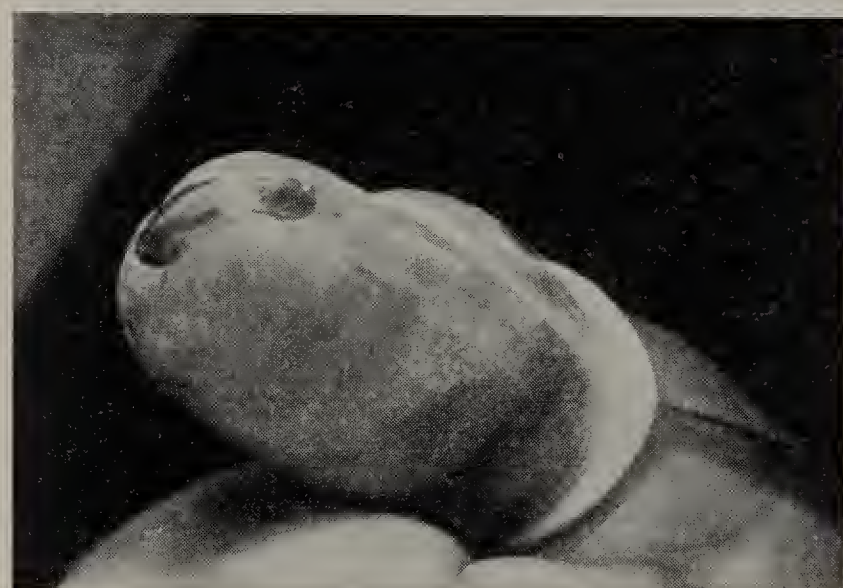


Fig. 2.—Open-ended tube for the measurement of intra-oral air pressure positioned at the finger tip by a thin finger-stall.

Presented at the Research Meeting held on 14 May, 1970.

held in place by a thin rubber finger-stall. This finger-stall was perforated at its apex so that the transducer tube passed outside the finger-stall here and then passed in again. Where the tubing was outside the finger-stall, part of its wall was cut away as illustrated (*Fig.* 2). This method ensured that the tube was open at the finger-tip

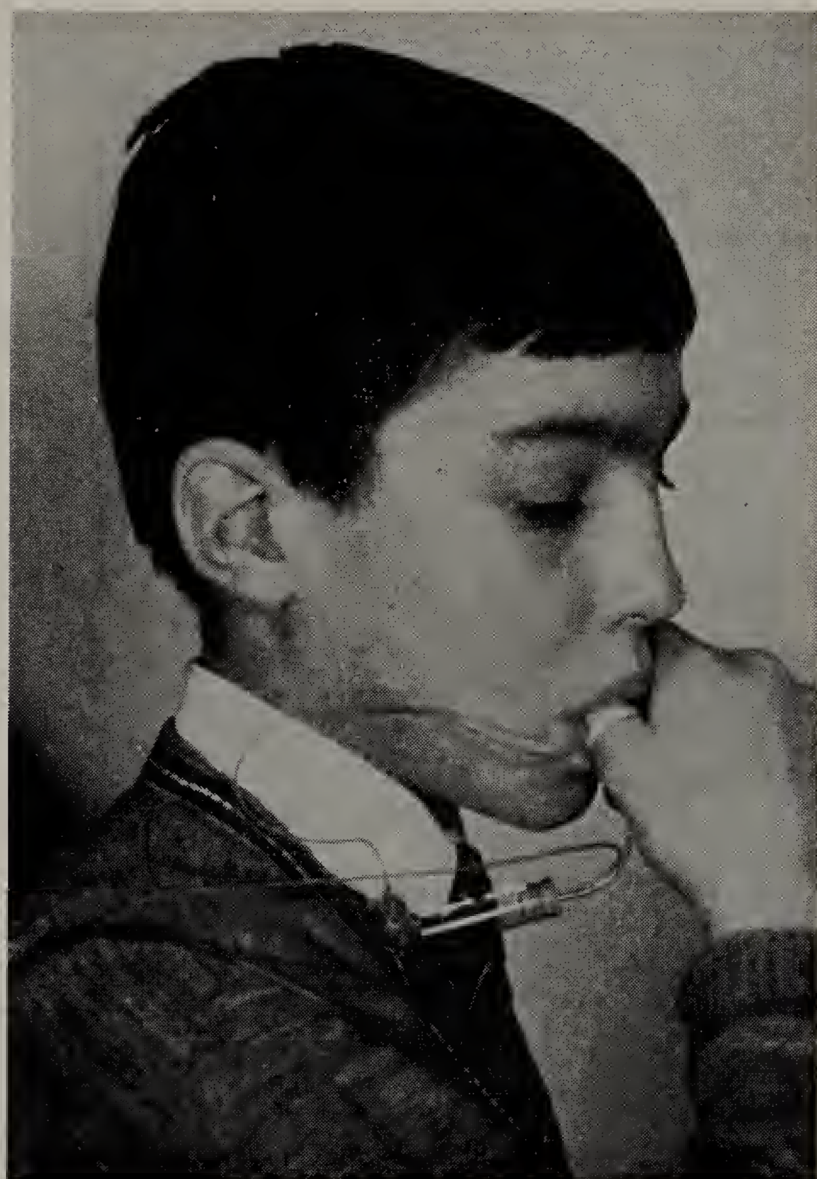


Fig. 3.—Method of recording intra-oral air pressure during finger-sucking, showing saliva trap.

and remained firmly in place. To ensure an air-tight seal between the finger and the transducer tube a very small quantity of petroleum jelly was used inside the finger-stall. To block the passage of saliva along the transducer tube a short, wide-bore, clear acrylic cylinder was inserted to act as a saliva trap (*Fig.* 3).

The children brought their chosen books or comics to a recording session. After the sensors had been positioned, a period of familiarization was allowed and then buccal pressure was recorded over a 2-minute period whilst the child was seated comfortably reading. At the end of this period the recorder was stopped temporarily whilst the child was encouraged to indulge his sucking habit in his accustomed manner. When it was felt that the sucking habit was operating at a steady level and the child was again engrossed in his reading, the recorder was restarted and a further 2-minute recording was made. At the beginning and end of each recording session, the sensors and integrator were calibrated.

Parts of the records made while subjects were finger-sucking are shown in *Fig.* 4, and illustrates the type of information obtained. The upper trace denotes negative pressure in the region of the finger tip and becomes increasingly negative towards the centre of the chart. The lower trace shows pressure buccal to the upper first permanent molar and increases towards the centre of the chart. For each trace a base line has been constructed by joining the trace marks obtained when the mouth was open and the cheek was held clear of the buccal sensor with a mouth mirror.

The central trace records the signal from the integrator which is adding up the total buccal pressure. When this sum reaches a pre-set level the integrator resets and begins another addition. Thus by counting the number of integrator peaks obtained in a given period, total pressure during different activities may be compared. Subject R.W. (*Fig.* 4A) showed a considerable lingual negative pressure, often sustained for many seconds while finger-sucking. During rest, there was a fairly steady buccal pressure of about 6 mm. Hg. While sucking, the buccal pressure was raised considerably showing a background pressure varying between 9 and 28 mm. Hg interspersed with peaks up to 87 mm. Hg. Increases in lingual negative pressure were generally, but not invariably, accompanied by a rise in buccal pressure. Buccal pressure peaks, however, often occurred alone.

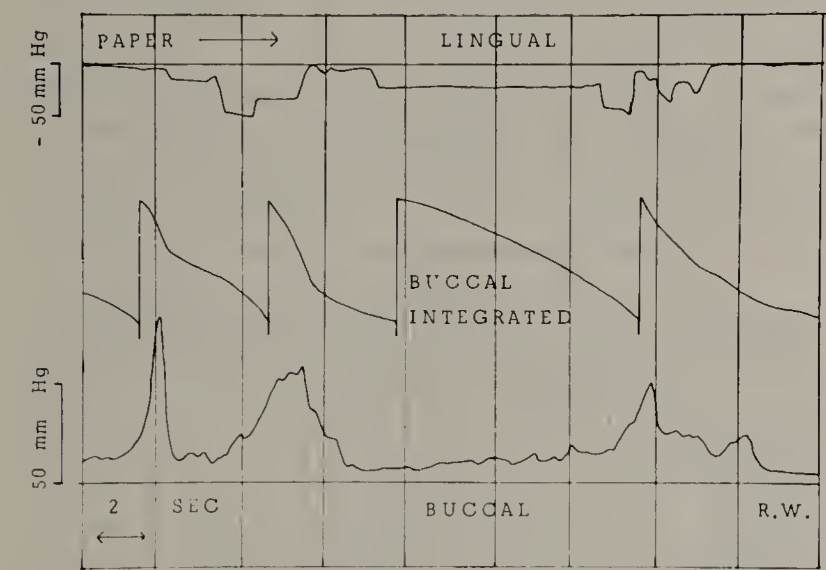
Subject A.B. (*Fig.* 4B) also showed a considerable lingual negative pressure maintained over many seconds during finger-sucking. In this subject, however, negative peaks often occurred unaccompanied by any rise in buccal pressure, although the general level of buccal pressuıe was greater during sucking than at rest.

Subject K.M. (*Fig.* 4C) developed much lower pressures than either subjects R.W. or A.B. For most of the time no negative lingual pressure was maintained but occasional small peaks occurred and these were usually accompanied by buccal peaks.

From an inspection of the pressure records it was clear that there was considerable variation in the way that subjects sucked their fingers. Some produced large sustained negative pressures while some showed no negative pressure except for occasional small peaks. Some showed a large increase in buccal pressure during sucking while one showed virtually no change. The general appearance of the pressure traces suggested that those subjects who produced most negative pressure during sucking also produced the greatest increase in buccal pressure.

Integrated buccal pressure was compared between resting and sucking by counting the number of integrator peaks produced during a 2-minute period of each activity. Using the

integrator calibration these figures have been expressed as millimetres of mercury per minute and are shown in *Table I.* Two columns show the integrated pressure recorded during 2 minutes resting and 2 minutes sucking for each subject, and the last column roughly indicates the size of



A

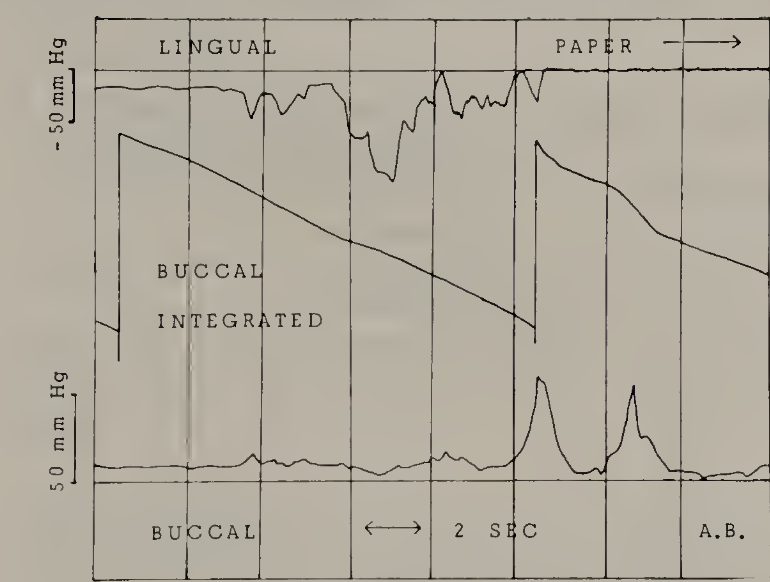
Fig. 4.—Sections of records of subject R.W. (A), subject A.B. (B), and subject K.M. (C) whilst finger-sucking. In each the chart is moving from left to right and the vertical marker lines denote 2-second intervals. The upper trace denotes negative pressures at the finger tip and becomes increasingly negative towards the centre of the chart. The lower trace shows pressure buccal to the upper first permanent molar and increases towards the centre of the chart. The central trace shows integrated buccal pressure.

Table I.—Integrated Buccal Pressure exerted over the Upper First Permanent Molar during a 2-minute Period whilst at Rest and during Sucking

Subject	Pressure (mm. Hg per minute)		Sucking: Resting Pressure Ratio
	Resting	Sucking	
R.W.	2·6	16·8	+++
A.B.	10·8	18·1	++
S.C.	8·9	14·4	++
L.M.	8·2	10·8	+
K.M.	9·6	11·3	+
M.F.	13·6	15·2	+
I.D.	12·9	14·4	+
E.F.	15·8	17·1	+
M.C.	8·0	8·6	=

the difference between the two activities. Eight out of 9 subjects showed some increase in buccal pressure during sucking but this was only marked in the first 3 subjects. To aid clarity the ratio of sucking to resting pressure is roughly indicated by plus marks on the following tables.

The age and sex of each subject is shown in *Table II.* Most were girls but there seems to be no correlation between these factors and sucking intensity, or indeed with the finger that was sucked as is illustrated in *Table III.* The thumb, designated 1, was the digit most commonly



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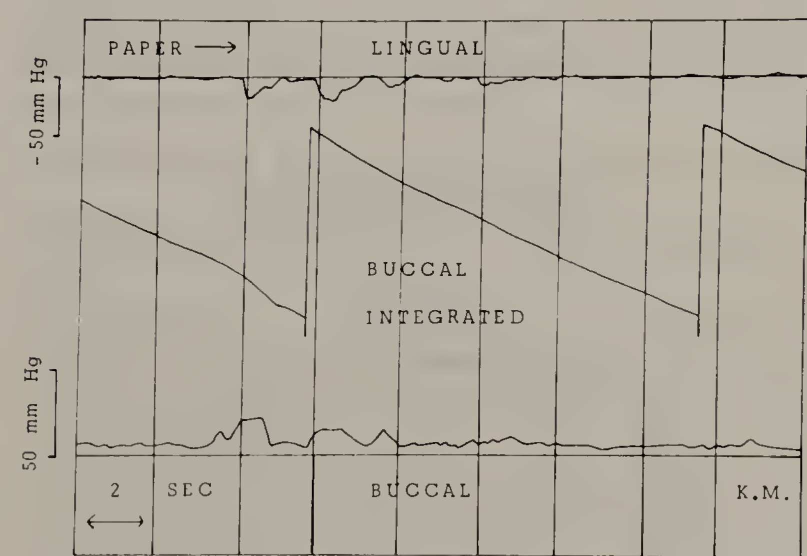

C

sucked, and sucking was more frequent on the left side than on the right.

After the pressure data had been gathered an attempt was made to see whether any correlation could be found between differences in the occlusion and the type of sucking activity recorded. Most subjects presented a Class II, division 1 type of occlusion with a Skeletal II dental base relationship. Subject R.W., for example, showed proclination of the upper incisors, especially on the left, with some retroclination of the lower incisors, and an anterior open bite. The upper arch looked narrow and there was mandibular deviation to the right on closure producing a unilateral crossbite. Another interesting feature was the occurrence of a tongue thrust in 6 subjects and mildly lisping speech in the same number. These factors, however, did not seem to be associated with the occurrence of high buccal pressure.

Measurements were taken from study models in an attempt to see whether the width of the

maxillary arch was related to the intensity of sucking activity. Measurements of intermolar width were made between the tips of the mesio-lingual cusps of the maxillary first permanent molars in the manner described by Moorrees (1959) and these measurements were compared with those from his published sample of 184 North American children (*Table IV*). In subject I.D., one upper first permanent molar had been extracted so that the comparison was based upon the distance between second deciduous molars.

Table II.—Age and Sex of Subjects related to the Sucking : Resting Pressure Ratio

Subject	Sucking: Resting Pressure Ratio	Age	Sex
R.W.	+++	10	F
A.B.	++	10	F
S.C.	++	8	F
L.M.	+	15	F
K.M.	+	9	M
M.F.	+	9	F
I.D.	+	11	F
E.F.	+	10	F
M.C.	=	13	M

Table III.—Digit Sucked related to the Sucking: Resting Pressure Ratio

Subject	Sucking: Resting Pressure Ratio	Digit*
R.W.	+++	L 2
A.B.	++	R 1
S.C.	++	L 1
L.M.	+	L 2
K.M.	+	L 1
M.F.	+	L 1
I.D.	+	R 3 + 4
E.F.	+	L 2 + 3
M.C.	=	R 1

*The digits were numbered starting with the thumb designated 1.

Three subjects showed intermolar widths considerably less than the mean of Moorrees' sample and outside the range of one standard deviation. *Table V* relates sucking intensity and intermolar width and it appears that the 3 subjects who showed the greatest increase in buccal pressure during sucking also exhibit some narrowing of the maxillary arch. Only 1 subject (R.W.), however, showed a unilateral crossbite.

In discussing the results obtained in this study it is seen that most subjects showed some increase in total buccal pressure during sucking activity. This increase was sometimes accompanied by the production of a negative intra-oral pressure but often occurred alone. It, therefore, seems likely that more than one mechanism contributes to this increase in buccal pressure.

Firstly, during sucking, the mandible appears to drop a little and orbicularis oris contracts around the finger to produce an anterior oral seal. Both these actions would be expected to cause some increased tension of the cheek against the teeth, irrespective of any negative pressure that was produced.

Table IV.—Intermolar Widths Measured between the Tips of the Mesiolingual Cusps of the Maxillary First Permanent Molars

Subject	Intermolar Widths (mm.)		Arch Narrowness in Present Sample
	Present sample	Moorrees sample	
R.W.	33·5	39·3±2·6	---
A.B.	35·4	38·4±2·4	--
S.C.	31·9	38·4±2·4	---
L.M.	41·3	39·3±2·4	
K.M.	39·1	39·5±2·8	
M.F.	37·4	39·1±1·9	
I.D.*	34·0	34·9±2·9	
E.F.	40·9	39·3±2·6	
M.C.	41·9	40·8±3·2	

*Width based on distance between second deciduous molars.

Table V.—Sucking: Resting Pressure Ratio related to Intermolar Width and Crossbite

Subject	Sucking: Resting Pressure Ratio	Inter-molar Width	Cross-bite
R.W.	+++	---	R
A.B.	++	--	
S.C.	++	---	
L.M.	+		
K.M.	+		
M.F.	+		
I.D.	+		
E.F.	+		
M.C.	=		

Secondly, where negative pressure is produced in the vault of the palate, this may be transmitted through to the buccal sulcus and so allow atmospheric pressure to force the cheeks against the teeth. Walpole Day and Foster (1970), however, have pointed out the importance of tongue posture in this respect, for unless the air space enclosed by the tongue encroaches on the lingual surfaces of the cheek teeth, variations in palatal

pressure will not extend to the buccal sulcus. The examples seen in this study where a lingual negative pressure was not accompanied by any increase in buccal pressure may thus be explained on the basis of the presence of a high tongue posture.

Thirdly, as a general observation of the subjects involved in this study it appeared that swallowing occurred more frequently during sucking activity than whilst at rest. It seems probable that the presence of a finger in the mouth may increase salivary flow, so that more frequent clearance of saliva from the buccal sulcus and deglutition may contribute to the rise in total buccal pressure generally observed.

Of the 9 subjects studied only 3 showed a narrower than average maxillary arch and only 1 of these exhibited a unilateral crossbite. Ruttle and others (1953) in a study of 36 finger-suckers could find no difference in maxillary arch width between finger-suckers and a control group. Bowden (1966), in his study of 116 Melbourne children aged 2–8 years, was unable to find any statistically significant difference in the incidence of crossbite between those with a sucking habit and those without. Leighton (1966), however, in a longitudinal study of 19 children with crossbites showed that not only did the upper arch become narrower, but the lower arch became wider in comparison with a normal control group. Sucking habits were more frequent amongst the crossbite cases and he speculates whether this reflects a lack of outward pressure from the tongue against the palate during finger-sucking.

This conflict of evidence implies that in most finger-suckers the habit has only a slight influence upon maxillary arch width. The present study, however, does suggest that there are a small number of finger-suckers who produce an unusually large buccal pressure whilst they are sucking and that this may be associated with some narrowing of the maxillary arch and even crossbite whilst the habit is still active.

SUMMARY

1. Not all finger-suckers develop a negative lingual pressure during sucking.
2. Where a negative pressure is produced this does not always coincide with an increase in the pressure of the cheeks against the teeth.
3. Three subjects who showed the great increase in buccal pressure during sucking also showed some reduction in width of the maxillary arch.

Acknowledgements

I am indebted to the Medical Research Council and to the Clinical Physics Department of the Western Regional Hospital Board for the provision of apparatus, and gratefully acknowledge the generous co-operation of patients and staff at the Glasgow Dental Hospital.

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AUTOMATED MEASUREMENTS OF PHOTOGRAPHS AND RADIOGRAPHS

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DIRECT measurement of photographs and radiographs is time-consuming and liable to error in transcription of data. An alternative is to record and store points as rectangular co-ordinates, permitting calculation of lengths, angles, and other relationships between groups of points. Automatic recording offers advantages of speed and accuracy and the data is particularly suitable for computer handling.

A simple record reader (such as described by Barrett, Brown, and McNulty, 1968) offers advantages over direct measurement but the process is still slow. On the other hand, fully automatic scanning as suggested by Walker (1967) requires elaborate and expensive equipment.

The Microtrace system* (*Fig.* 1) offers the possibility of simple and rapid semi-automatic recording of co-ordinate points together with the immediate calculation of required dimensions. The system comprises a Micro 16 digital computer which performs all measurement calculations, a Teletypewriter for commanding the system and for printing out results, and a D-Mac reading table on which photographs, radiographs, tracings, projected images, or other similar subjects are placed.

Two separate computer programmes of particular orthodontic interest are available, Skullscan and Mapscan.

When using Skullscan, the crosswires of the reader pen are located over points in sequence. The pen push button is depressed at each position causing the computer to store and index with a reference number the co-ordinates of that point. Subsequent calculations are performed by the computer in response to commands fed in on the Teletypewriter and the answers are printed out. Calculations which can be undertaken include, the distance between two points, the angle between two lines, the perpendicular distance of a point from a line, and the definition of the co-ordinates of the base of a perpendicular or of the intercept of two lines. By appropriate combination of these basic calculations, quite complex systems of analysis may be undertaken.

With Mapscan the lengths of irregular lines or areas enclosed by them can be calculated. Lines or areas to be measured are traced using the reader pen whose position is digitized by the reader table. An immediate printout of results calculated by the Micro 16 is produced via the Teletypewriter. One of many possible applications is the measurement from photographs of models of the relationship between tooth size and arch size.

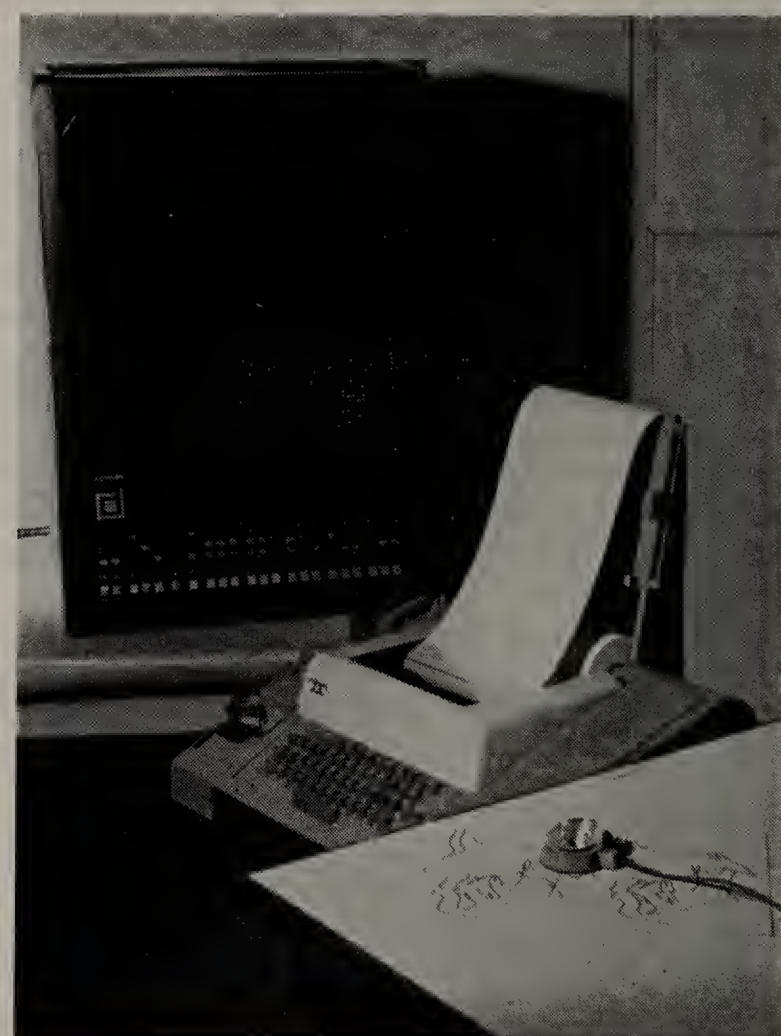

Fig. 1.—The Microtrace system.

*Digico Ltd., The Wynd West, Letchworth, Herts., England.

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Demonstration given at the Country Meeting held on 15 May, 1970.

A PRELIMINARY REPORT ON THE SEVERING OF GINGIVAL FIBRES FOLLOWING ROTATION OF TEETH

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THE histological work of Reitan (1959) and Edwards (1968), and the animal experiments of Wiser (1966) and Brain (1969) would seem to indicate that a derangement of the gingival fibres of the periodontal ligament, surrounding a rotated tooth, might be partly responsible for the relapse which is such a common feature following rotation. It would also seem that severing of these fibres might help to reduce this relapse. We felt that such a severing was commonly carried out in the course of surgical procedures, and was safe. It was therefore decided to do this, as a pilot study, on a small number of individuals.

Four patients were selected in whom a single tooth had been rotated. The band on the affected tooth was removed, and measurements made of the pockets on mesial, distal, buccal, and lingual aspects of the affected and contralateral teeth. Under local anaesthetic, using a vertical incision, the gingival fibres were severed as close to the cementum as possible. The instrument used was a Barraquer blade breaker containing a carbon steel razor blade, 0·12 mm. in thickness. The pockets, 2–4 mm. in depth before operation, were increased to 4–6 mm. following surgery. They had in all cases reduced to their preoperative depth 4–6 weeks later.

Study models were available at the beginning of treatment and were taken at the time of operation and then at a later date, as shown in *Table I*. The rotations were retained for a variable time from 3 to 18 weeks. Enlarged outlines of the teeth were traced on to tracing-paper by projecting them on a copy scanner; the models were first trimmed so that the base was parallel to a plane joining the mesiobuccal cusps of the first molars and incisal edge of a selected central incisor. The incisal edge of the rotated tooth was marked by a dot at its mesial and distal ends, these dots transferred to the tracing-paper, and a line drawn between them which was extended to the margins of the paper. Tracings were then superimposed and the angles between the incisal edge lines measured, this representing the amount of rotation between the radiographs. All models for the first three cases were traced twice, as a check on accuracy. There were eight pairs of measurements, and the average difference between pairs was 2·6° with a range from 0·5° to 4·5°. It is hoped to improve this standard of accuracy.

Table I.—RESULTS OF THE SEVERING OF GINGIVAL FIBRES FOLLOWING ROTATION OF TEETH

CASE	TOOTH CONCERNED	RETENTION	ROTATION	TIME OBSERVED	RELAPSE	PERCENTAGE RELAPSE
1	$\underline{\lvert 3}$	8 wk.	55°	4 mth.	13·5°	24·5
2	$\underline{2\rvert}$	3 wk.	37°	5 mth.	12·5°	33·7
3	$\underline{\lvert 3}$	18 wk.	56·5°	2 mth.	6·0°	10·6
4	$\underline{\lvert 3}$	10 wk.	42·5°	1 mth.	8·5°	20·0

The results are shown in *Table I*. It will be seen that all cases relapsed following severing of the fibres, but in no case was the relapse severe. In Cases 1 and 2 the tooth had been over-rotated, and the amount of relapse was sufficient to produce a clinically good result. It is felt that this small operation is safe, causes the minimum of

Presented at the Research Meeting held on 14 May, 1970.

discomfort, and very probably reduces the amount of relapse and/or the length of retention. We are proposing to extend the study to a larger group of individuals, together with a control group.

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COMPARISONS OF CRANIOFACIAL FEATURES IN MONOZYGOUS AND DIZYGOUS TRIPLETS

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INTRODUCTION

SEVERAL authors have investigated the degree of resemblance of various craniofacial features between family members. Wylie (1944), in a study of craniofacial patterns of 15 families, 13 of which contained a pair of same-sex twins, found that many twins showing outward similarity showed dissimilarity in the craniofacial pattern. He did not, however, assess the zygosity of the twin pairs. Snodgrasse (1948), studying a pair of female twins and their 4 siblings and parents, found evidence of a genetic pattern in dentofacial form. Curtner (1953), in an examination of 5 families, found varying types and degrees of conformity of craniofacial outlines between parents and children, some children conforming closely to the father, others to the mother, and in some cases children tended to conform to the father in some parts of the craniofacial skeleton and to the mother in other parts. Lundström (1954), in a study of 50 identical and 50 fraternal twins, found that genetic factors were more significant than non-genetic factors in the form of the facial profile. Brown (1961), in a cephalometric study of parents and their children, found evidence of some genetic influence on the endocranial and mandibular outlines. Hunter (1965), studying 37 identical and 35 fraternal twin pairs by means of cephalometric measurements, found that the genetic influence was stronger in determining dimensions of facial height than of facial depth.

Most of these studies have been on twins or family groups. There have been relatively few studies on triplets. Kraus, Wise, and Frei (1959), studying the craniofacial complex in 6 sets of triplets of varying zygosity, concluded that the form of the individual bones making up the skull is to a large extent under genetic control, but that environment plays a major role in determining how the various bony elements combine to achieve the total form of the craniofacial skeleton. Burke (1968) has also reported on the facial growth of a set of female triplets over a 4-year period.

In order to further the study of the influence of inheritance on the form of the craniofacial skeleton, facial and dental features of 3 sets of triplets of varying zygosity were examined.

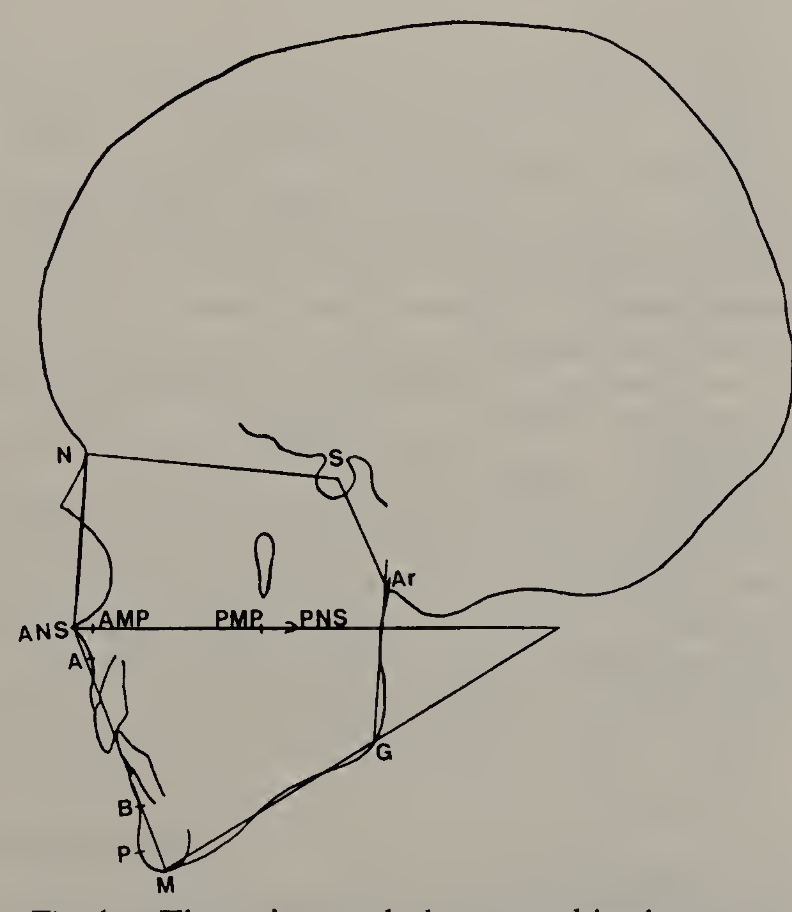

Fig. 1.—The points and planes used in the assessment of craniofacial features.

MATERIAL AND METHODS

The 3 sets of triplets who formed the subjects of this study were all same-sex triplets. They comprised 1 set of female triplets aged 5 years and 2 sets of male triplets aged 6 years and 10 years at the time of the study.

Presented at the Research Meeting held on 14 May, 1970.

1. Assessment of Zygosity

Zygosity was assessed by means of blood grouping, fingerprint patterns, and ridge counts. The results of the zygosity assessment tests strongly indicate that triplets P (female) and B (male) are monozygous and triplets A (male) are dizygous, having two members (Douglas and Robert) who are monozygous and a third member (Charles) who is genetically separate.

2. Assessment of Craniofacial Features

The craniofacial features were assessed by means of measurements on standardized lateral skull radiographs, using the facial polygon formed by the points Nasion (N), Sella (S), Articulare (Ar), Gonion (G), Menton (M), and Anterior Nasal Spine (ANS). In addition the maxillary plane was assessed as the plane joining the Anterior Nasal Spine (ANS) and the Posterior Nasal Spine (PNS), and the axial inclinations of the upper and lower incisors were assessed, the upper to the maxillary plane and the lower to the mandibular plane. Points A and B and Pogonion (P) were also determined. The Anterior Maxilla Point (AMP) was assessed as the point where a perpendicular from point A to the maxillary plane meets the maxillary plane. The Posterior Maxilla Point (PMP) was assessed as the point

Table I.—CRANIOFACIAL MEASUREMENTS IN THREE SETS OF TRIPLETS;

FEATURE	TRIPLETS P (monozygous)				TRIPLETS B (monozygous)				TRIPLETS A (dizygous)			
									Monozygous			
	Alison	Nicola	Wendy	Maximum difference	Stephen	Robert	Richard	Maximum difference	Robert	Douglas	Charles	Maximum difference
a. Cranial base												
Length N–Ar	82	83	81	2	85	85	83	2	99	99	91	8
Angle N–S–Ar	125°	125°	123°	2°	128°	127°	119°	9°	135°	132°	117°	18°
Anterior length N–S	63	61·5	62	1·5	62·5	63·5	62	1·5	73	72·5	72	1
Posterior Length S–Ar	27	30·5	27·5	3·5	31	30	32	2	32·5	34·5	32	2·5
b. Maxilla length AMP–PMP	46	45	45·5	1	45	45	45·5	0·5	47	47	49	2
Total face height N–ANS–M	103·5	103	103·5	0·5	110	108·5	115·5	7	124	121	119·5	4·5
Upper face height N–ANS	46	45·5	44·5	1·5	47	44·5	46·5	2·5	55·5	55	53	2·5
Lower face height ANS–M	57·5	57·5	59	1·5	63	64	69	6	68·5	66	66·5	2·5
c. Mandible length Ar–M	87	83	83	4	84	84·5	84	0·5	90	89	100	11
Gonial Angle Ar–G–M	132°	124·5°	132°	7·5°	136°	132·5°	137°	4·5°	112°	121·5°	126°	14°
Ramus height Ar–G	37	37	37	0	36·5	36	36·5	0·5	38·5	32	47	15
Body length M–G	57	56	53·5	3·5	55	56	53·5	2·5	68·5	68	66	2·5
d. Jaw relationship												
Ar–ANS–P	89°	84°	84°	5°	79°	78°	76°	3°	76°	76·5°	86°	10°
ANS–PNS/M–G	29°	27°	31°	4°	37°	38·5°	42·5°	5·5°	29·5°	32°	26°	6°
S–N–A	80°	82°	81°	2°	79·5°	78°	83·5°	5·5°	70·5°	71°	81°	10·5°
S–N–B	76°	77°	77°	1°	72·5°	71·5°	75°	3·5°	65°	65·5°	77°	12°
ANS–Ar–M	41°	41·5°	42·5°	1·5°	45°	46·5°	50°	5°	45°	44°	41°	4°
e. Upper incisor/ maxillary plane	85°	92·5°	90°	7·5°	86°	79°	82°	7°	101°	102°	96°	6°
Lower incisor/ mandibular plane	74°	80·5°	74·5°	6·5°	82°	86°	72°	14°	100°	93°	90°	10°

N.B. Linear measurements are in millimetres.

where a perpendicular from the lower end of the pterygomaxillary fissure shadow to the maxillary plane meets the maxillary plane. With the exception of AMP and PMP the points and planes used in the assessment were as described by Graber (1958) and are shown in *Fig.* 1.

The measurements were grouped into 5 subdivisions as follows:—

a. Cranial base measurements: Cranial base length N–Ar. Cranial base angle N–S–Ar. Anterior cranial base length N–S. Posterior cranial base length S–Ar.

ably greater than in the monozygous triplets. These were: Cranial base length N–Ar. Cranial base angle N–S–Ar. Mandibular length Ar–M. Anteroposterior maxillary/mandibular relationship Ar–ANS–P. Anteroposterior position of maxilla S–N–A. Anteroposterior position of mandible S–N–B.

The dizygous triplets also showed considerably greater variation in two other features, viz., gonial angle Ar–G–M and ramus height Ar–G, but in these features the variation between the monozygous pair in triplets A was greater than

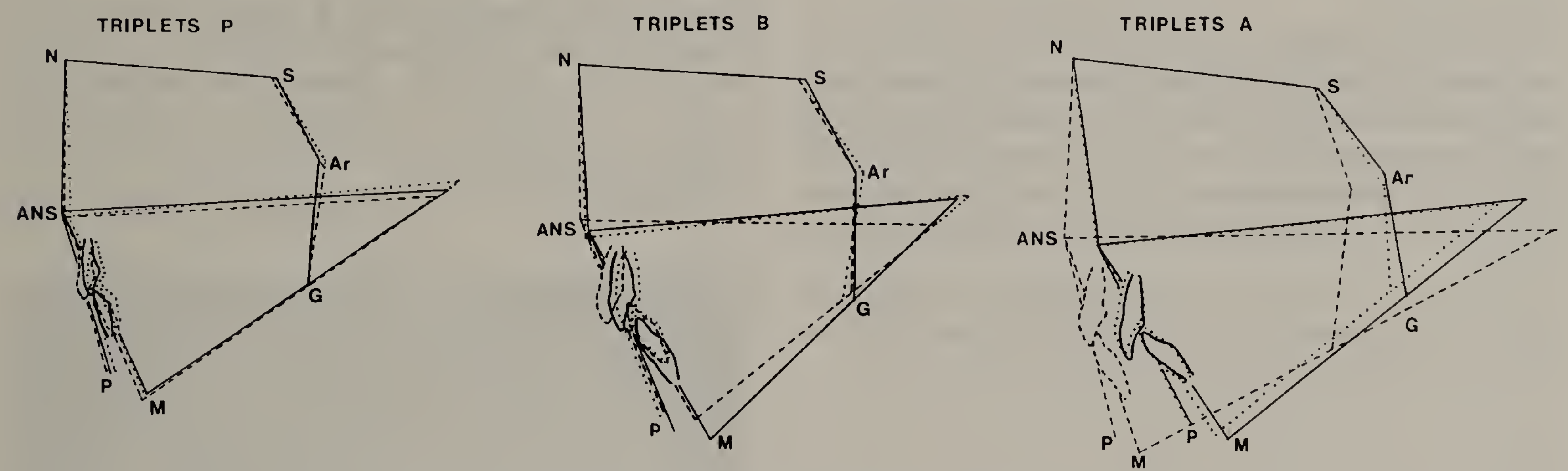

Fig. 2.—Superimpositions of the tracings of the facial polygons of the triplet sets. In triplets A the broken line denotes the genetically separate individual (Charles).

b. Maxillary length and facial height: Maxillary length AMP–PMP. Total face height N–ANS–M. Upper face height N–ANS. Lower face height ANS–M.

c. Mandibular measurements: Overall mandibular length Ar–M. Gonial angle Ar–G–M. Ramus height Ar–G. Mandibular body length M–G.

d. Relationship of jaws to each other and to upper face: Anteroposterior relationship mandible to maxilla Ar–ANS–P. Vertical relationship mandible to maxilla ANS–Ar–M. Vertical relationship mandible to maxilla ANS–PNS/M–G. Anteroposterior position of maxilla S–N–A. Anteroposterior position of mandible S–N–B.

e. Axial inclinations of incisor teeth to dental bases: Inclination of upper incisor to maxillary plane. Inclination of lower incisor to mandibular plane.

RESULTS

The results of the measurements are shown in *Table I.* It can be seen that for several of the features measured there is little difference in the degree of variation within the triplet groups between the monozygous and the dizygous triplets, and in some features the dizygous triplets even varied slightly less than the monozygous triplets. However, in some respects the variation in the dizygous triplets was consider-

the variation between the third member and the nearest of the monozygous pair.

Thus it can be said that as far as the individual measurements were concerned the main difference between the monozygous and the dizygous triplets was the greater variation in the dizygous triplets for the measurements involving cranial base length and angle, mandibular length, and anteroposterior relationship of the jaws.

In order to emphasize the essential differences in variation between the 3 sets of triplets the facial polygons of the individuals in each set were superimposed. The superimpositions are seen in *Fig.* 2. Triplets P and B and the monozygous pair from triplets A showed close similarities in the facial polygon and the position of the teeth, while the third member of triplets A was markedly different from his brothers.

DISCUSSION

In a previous study of triplets, Kraus, Wise, and Frei (1959) found that superimposition of the tracings of facial polygons of twin pairs from within the triplet groups showed no difference in concordance or discordance between monozygous twin pairs and dizygous twin pairs. The present study suggests that if the facial polygons of the complete triplet sets are superimposed the dizygous triplets do show greater discordance than the monozygous triplets. The individual measurements within the facial polygon in the

present study showed that only for a few features did the dizygous triplets differ more than the monozygous triplets, and yet the total form of the face as assessed from the superimposition was considerably different in the odd member of the dizygous triplets. It would seem, therefore, that a number of small differences in the various features within the facial skeleton are compounded to make the overall larger difference in the total form of the face and the position of the dentition.

SUMMARY

Craniofacial features of 3 sets of triplets were assessed by means of measurements on standardized lateral skull radiographs. Blood grouping and fingerprint ridge counts indicated that 2 of the triplet sets were monozygous and the third set contained 2 monozygous and 1 separate individual.

Only in a small number of the individual features measured did the dizygous triplets show greater differences than the monozygous triplets, but on superimposition of the tracings of the triplet sets a much greater difference in the overall conformation of the face was seen in the dizygous triplets. This suggests that small differences in the individual components of the face are compounded to make the larger overall differences in facial form.

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A METHOD OF TREATING TOTAL LINGUAL OCCLUSION

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CONSIDERABLE bilateral expansion of the buccal segments, especially in the lower arch, is a difficult mechanical problem. In respect of this tooth movement, a combination of appliances to treat a Class II, division 2 malocclusion in which there was total lingual occlusion of the mandibular teeth (*Fig.* 1) was devised.

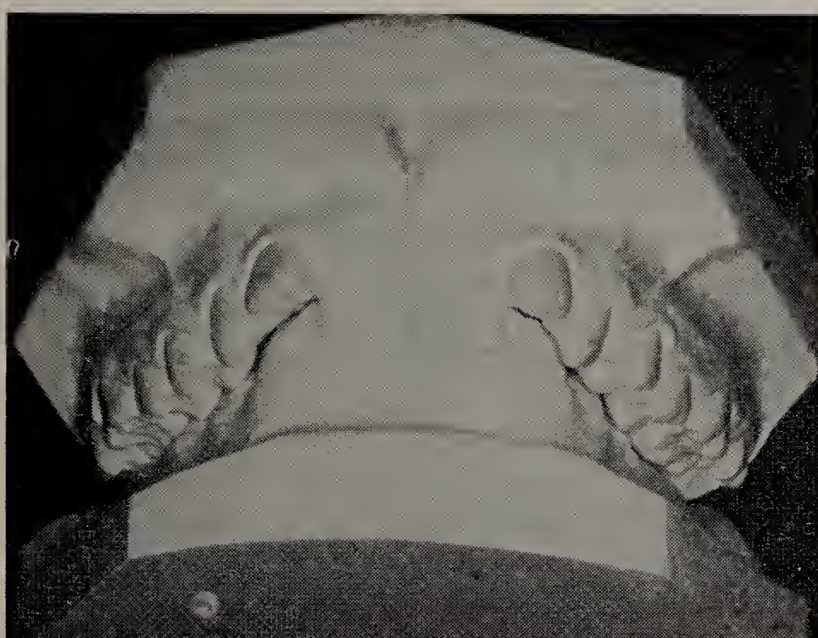

Fig. 1.—Model showing a Class II, division 2 malocclusion in which there is a total lingual occlusion of the mandibular teeth.

The Upper Appliance

The upper appliance was removable, cribbing 73|37 and carrying overlapping finger springs to move 65|56 palatally after 4|4 had been extracted. The appliance also carried a bite plane to assist overbite reduction and disengage the buccal segments during their correction.

The Lower Appliance

Teeth were not extracted from the lower arch and the lingual occlusion left little space for the attachment of brackets to the buccal surfaces of the lower teeth. It was, however, felt that a labial appliance would remain active over a greater degree of expansion than would those operating from the lingual aspect. A labial appliance was, therefore, designed to move the premolars and molars simultaneously.

The principles of labial expansion appliances have been previously recorded by, for example, Highton (1915) and Pitt (1922), both being applied to the upper arch in Class III cases. The present appliance was constructed as follows: bands were chosen for the first premolars and first molars on both sides and incorporated in a working model as shown in *Fig.* 2A. This model was made after the expansion was completed,

A B

Fig. 2.—Working model showing the labial expansion appliance in position.

Presented as a tape/slide demonstration at the Country Meeting held on 15 May, 1970.

when the second molars had erupted, but demonstrates the actual appliance used in the case. A piece of 1-mm. stainless-steel wire was soldered buccally on the bands as low as possible to avoid occlusal interference (*Fig*. 2B). To this was taped and soldered a 6-mm. length of 1-mm. stainless-steel tube opposite the second premolar.

Fig. 3.—Model showing the correction of the buccal occlusion after 6 months.

The expansion force was transmitted to the second premolars by a 1-mm. spur of stainless-steel wire soldered to the lingual of the first premolar bands. If the second molars had been erupted, a spur could have been placed against these teeth from the first molar bands. Activation came from a 1-mm. labial arch which engaged the buccal tubes against bayonet bends, and when in position the bow lay within 1·5 mm. of the attached gingivae of the incisor teeth. In order to insert the archwire, the ends had to be contracted 0·5 cm. on each side. When thus engaged in the tubes, the expansion force was approximately 200 g. on either side—the relative expansion of the molars and premolars being controlled by ' toe-in ' bends placed at the arch ends.

The appliances were well tolerated and efficient. The buccal occlusion being corrected in 6 months (*Fig*. 3). A 9·5-mm. expansion at the lower first premolars and a 10·5-mm. expansion at the lower first molars together with 5-mm. contraction of the upper first molars and 4·5-mm. contraction of the upper second premolars, was achieved without complications in 6 months with the combination of an upper removable appliance, and a simple but robust, labially activated, lower, fixed appliance. This is a combination of two appliances which deserves consideration when such a malocclusion is encountered in the future.

Acknowledgements

I am grateful to Dr. Mills for allowing me to use this patient as an illustration of the treatment, and for his guidance in the presentation. I am also indebted to Mr. J. Morgan of the Eastman Dental Hospital for his suggestions, advice, and considerable labour in presenting the photographic and sound material, and to Miss Snell and Miss Jeffery for their secretarial assistance.

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METHODS AVAILABLE TO IMPROVE THE SURFACE HARDNESS AND APPEARANCE OF STUDY MODELS

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INTRODUCTION

Orthodontic practice and study models are inseparable. Oliver, Irish, and Wood (1940) have listed eighteen reasons for producing models for every patient, from recording the case before treatment to the understanding of the ' biologic nature of orthodontia '.

A standardization of study models is most desirable and the method for producing them has been demonstrated by Adams (1970).

The models, once prepared and marked with the patient's name, number, and date are stored in boxes. In practice they are frequently handled and may be sent through the post. In a teaching hospital they are handled regularly by teacher, student, and nurse and as a result are vulnerable to injury, yet ' they are a record which can be replaced by nothing else ' (Bennett, 1931). In the same chapter Bennett suggested that the tooth portion of the model should be cast in artificial stone for strength while the base could be cast in plaster. This combination of strength and economy is still used by many dentists.

Many methods have been suggested for the protection of models including the use of stearine and the application of soap or varnish.

In a teaching hospital, it is customary to produce demonstration models in acrylic as described by Gibson (1949), Lyon (1952), and Morrant (1953) but there are two main disadvantages to this. The first is one of economics, i.e., time, labour, and materials; secondly, models lose something of their accuracy when duplicated in acrylic and accuracy is very important.

It was therefore decided to look again at the plaster model cast directly from the impression. The routine models cast in stone and based in plaster while possibly more durable do not give the same aesthetic satisfaction as 100 per cent plaster models, as will be discussed later. It was therefore decided to examine materials which could be easily applied to the finished plaster cast to improve its surface hardness and possibly its total strength.

The idea was not original. Trotter (1949) briefly mentioned a method of impregnating plaster models with a resin. The curing had to be completed by baking for an hour and the resin itself had a short shelf life. The idea was revived in 1962 by Hosoda, Otani, Hirano, and Fusayama using polystyrene dissolved in amyl acetate. In an interesting account on the preservation of fragile skull bones, removed from archaeological sites, Angel (1943) advocated impregnating them with polyvinyl acetate.

OBJECTIVE

The aim was to find a material which would improve the surface hardness of plaster study models and their resistance to impact, seal the surface against dirt, and improve the appearance of the model. The material should be easy to apply, inexpensive, durable, and not obscure the fine details of the cast.

MATERIALS

Several preparations used by orthodontists were tested—vinyl emulsion in aqueous dispersion (Plasterlac), sulphonated fatty acid (Modelgloss), copal varnish, and polyurethane and acrylic sprays. As the investigation progressed and further information became available from the manufacturers, our attention was drawn to the range of acrylic syrups for cold-curing

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Presented at the Country Meeting held on 15 May, 1970.

solventless coatings known as Acryloid and this material was added to the list of products.*

METHOD

Plaster specimens were prepared carefully to eliminate undesirable variables. Plaster and water were mixed in the ratio of 100 g. plaster to 50 ml. water. The mix was spatulated for 1 minute and vibrated into silastomer moulds (Van der Linden, 1965) to produce $\frac{1}{2}$-inch square rods for impact and transverse strength testing, and on to glass plates to produce a plaster tile with a compact surface for abrasion testing. Since one of the objectives was to obtain extra-hard models for demonstrations, test specimens were also prepared in regular dental stone and die stone mixed in a water: powder ratio of 25: 100 (Combe and Smith, 1964).

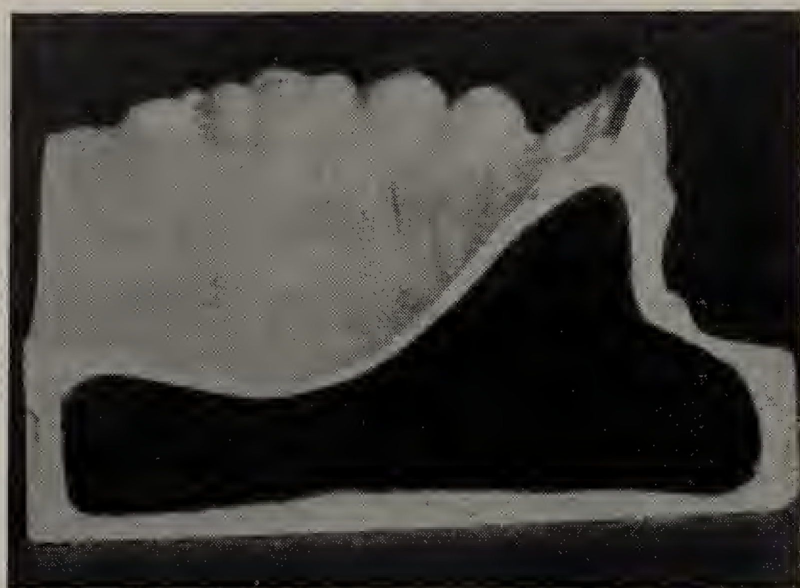

Fig. 1.—Stained model to show the degree of penetration of Acryloid.

To investigate the aesthetic appeal of the different coatings, rubber moulds were made from study models of a patient, and models of plaster, stone, and die stone were cast using standard powder: water ratios and vibrating the moulds.

Since the physical properties of gypsum products improve as excess water is lost to the atmosphere (Mahler, 1951; Combe and Smith, 1964) the test specimens were placed in a warm, dry store for 2 weeks, after which time the weight of the specimens was found to be constant and it was deduced that all excess water had evaporated.

The rod specimens were weighed and divided into batches of ten. Each batch of rods, with a pair of study models and a plaster tile, were coated with one of the materials according to the manufacturers' instructions. The varnish and vinyl solutions were applied by brush. The acrylic and polyurethane were supplied in aerosol tins and were thus sprayed on to the plaster. In using the sulphonated fatty acid the specimens were immersed for 30 minutes in the solution then washed in water and wiped dry. Two solutions of Acryloid were made up in tuluol, one of 10 per cent and one of 20 per cent solids. The specimens were immersed in the 10 per cent solution for 10 minutes then, when dry, dipped briefly in the 20 per cent solution and allowed to drain naturally.

Penetration

This was assessed by sectioning the models and examining the margins under a travelling microscope.

The vinyl material did not penetrate the plaster but formed a glossy skin in one application. The sulphonated fatty acid penetrated the plaster fully in the one immersion to produce a gloss. The first applications of varnish polyurethane and acrylic were absorbed. Two coats of varnish and four spray coats of polyurethane and acrylic were necessary to produce a glossy surface with a penetration of 8–20 μ. The Acryloid produced a surface gloss with a penetration of from 0·5 to 3·0 mm. (*Fig.* 1).

Impact Testing

In order to find out whether any of the coatings would help to reduce the incidence of chipped incisors on study models an impact test was designed as a preliminary investigation.

This test is not universally accepted since the results vary with the size and shape of the specimens, the weight and linear speed of the impact hammer, and the temperature (Skinner and Gordon, 1956). However, a simple comparison between similar specimens is possible. The commercial impact machines available in the University were too heavy so one was specially built by the Department of Mechanical Engineering (*Fig.* 2). It was designed so that an indicator should be moved over a degree scale by the swing of the hammer. The differences between the position of the indicator when the hammer swung freely (position 'A') and when it had struck a test specimen (position 'B'), angle Ø was taken as an indication of the resistance of that specimen to impact. The mean and standard deviation of the angles were calculated for each batch of plaster rods, and it was found that angle Ø was significantly greater at the 0·05 level for the rods covered in acrylic.

To confirm this trend a similar set of plaster rods was prepared to examine their transverse

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*Acryloid is obtainable from Synthetic and Industrial Finishes Ltd., Imperial Way, Watford, Herts.

Acrylic and polyurethane sprays from DCMC Industrial Aerosols Ltd., Edgware Road, London.

Modelgloss from Dentaurum, Pforsheim, Western Germany.

Varnish from Goodless Wall and Co., Liverpool.

Plasterlac from Camden Chemical Co., Gray's Inn Road, London.

strength (Combe and Smith, 1964), using the Instron machine (*Fig.* 3). This is a sophisticated machine which produces loads in compression and tension and records the stress on a specimen directly onto the graph paper (*Fig.* 4).

Analysis of the results showed that plaster impregnated with Acryloid resin was stronger than plaster covered with either varnish, vinyl, or sulphonated fatty acid (*Table I*).

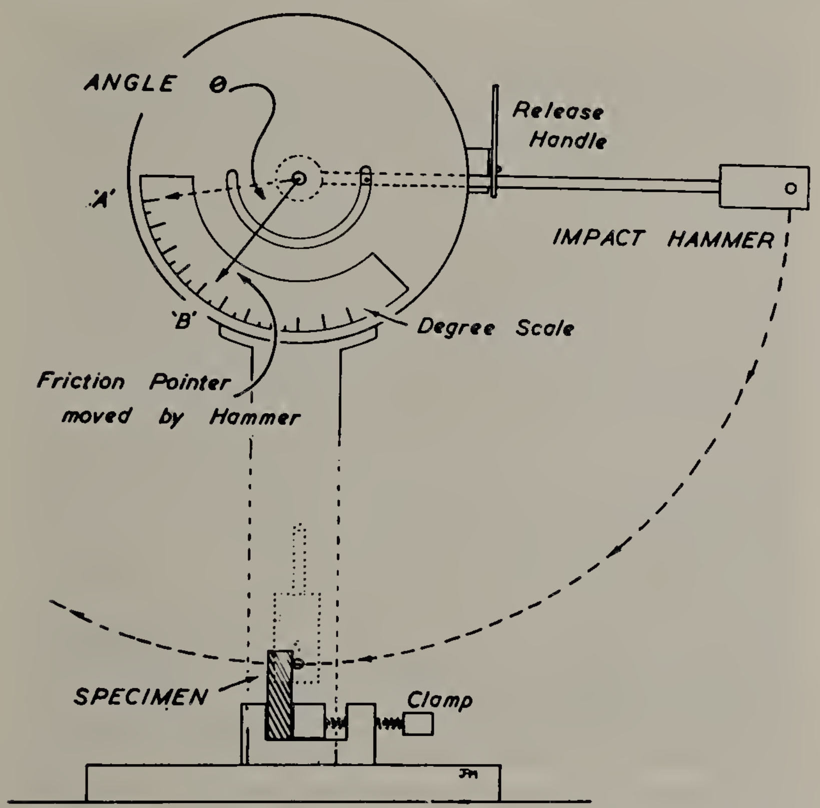

Fig. 2.—Diagram of impact machine showing free swing of hammer (position ' A ') and reduced swing after impact (position ' B ').

Abrasion Resistance

An instrument used in industry for comparing wear characteristics of paint and varnishes was used for this test which was essentially subjective. A hard nylon brush, the loading of which could be varied (*Fig.* 5), was moved back and forth over the specimen until wear of the surface was visible. The number of oscillations required to produce this wear, i.e., to dull a glossy surface or to remove the surface coating altogether, was an indication of the ' hardness ' of the coating.

The plaster tiles, covered with the sample coatings were subjected to 100 oscillations with 100-g. loading. The untreated plaster was heavily scored (top of *Fig.* 6) and the sulphonated fatty

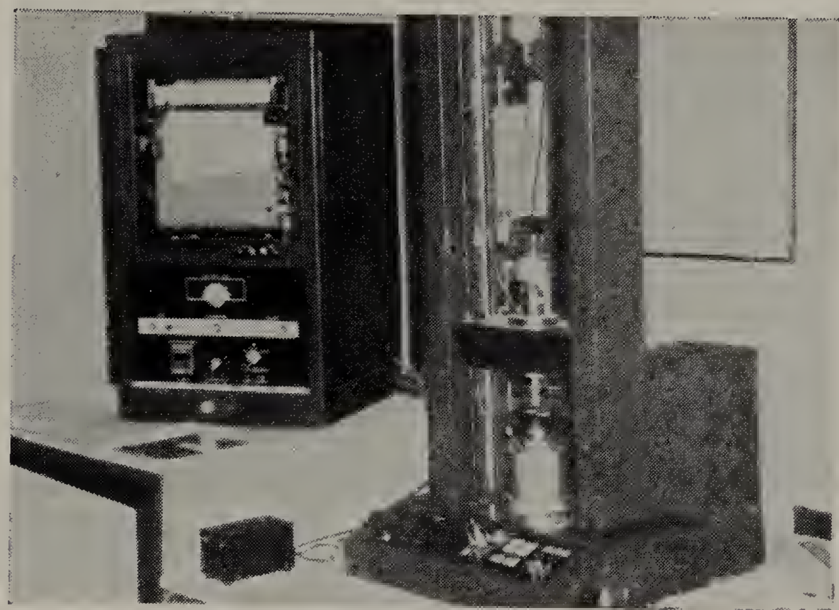

Fig. 3.—The Instron machine.

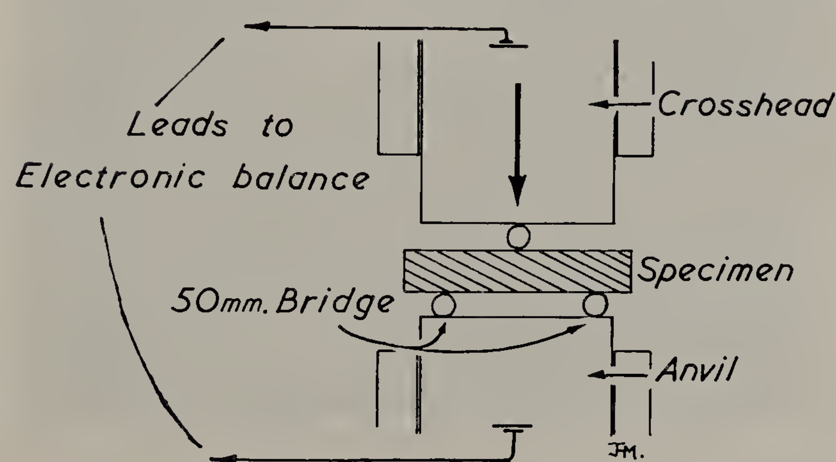

Fig. 4.—Diagram to show the placement of the rod specimen between the heads of the Instron machine.

Table I.—Transverse Strengths of Specimens measured by the Instron Machine

Material	Mean Reading of Instron Scale	Actual Breaking Stress (lb. per sq. in.)
1. Plaster untreated	4·55	1169
Plaster with varnish	5·18	1310
Plaster with fatty acid	5·20	1336
Plaster with vinyl	5·20	1336
2. Plaster with acrylic spray	6·50	1670
Plaster with polyurethane	6·55	1683
3. Plaster with Acryloid	7·75	1194
Model stone untreated	8·68	2259
Model stone with Acryloid	9·36	2406
4. Die stone untreated	11·89	3058

Differences occur between the four groups but no significant difference within the groups. Differences of 0·97 are significant at 0·001 level.

acid specimen slightly less so. Acrylic, polyurethane, varnish, and vinyl coatings were unaffected.

After 300 oscillations with a 500-g. loading, the vinyl surface peeled off. The polyurethane showed rather more abrasion than the acrylic and varnish coatings, but in none of them was the abrasion marked.

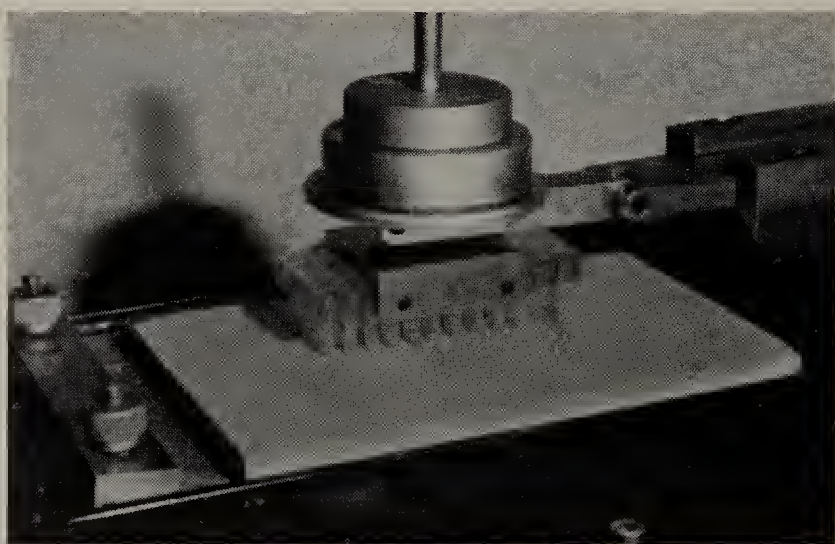

Fig. 5.—Nylon brush with 100-g. load to test abrasion resistance.

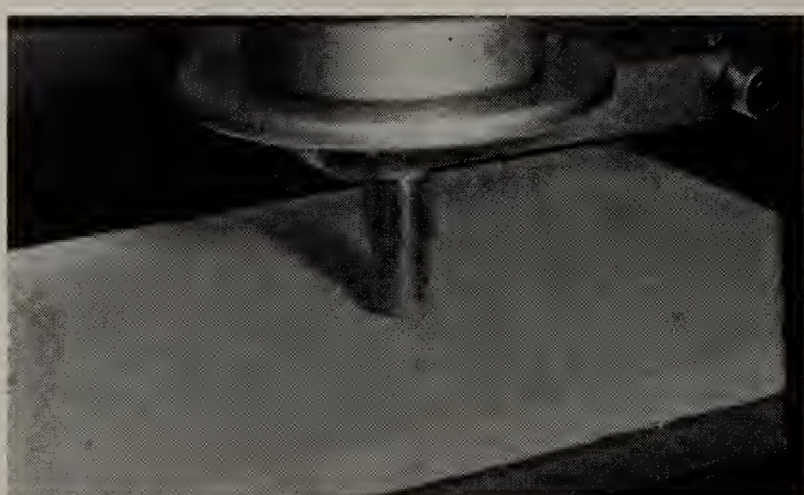

Fig. 7.—Steel scribe with 50-g. load.

Scratch Resistance

In order to obtain some numerical evaluation of the increase in surface hardness of the treated models and to confirm the trend shown by the abrasion test, a scratch test (after Ostlund, 1956) was performed. A hard steel scribe with a cone angle of 120° and loaded with 50 g. was drawn across the surface of each specimen (*Fig.* 7). The width of the scratch so produced (bottom of *Fig.* 6) was measured at five different places with a travelling microscope.

The results are shown in *Table II*. All the materials improved the resistance to scratching but the acrylic and polyurethane were better than the rest.

Aesthetic Evaluation

To assess the aesthetic appearance of each type of model and to find which coatings resisted normal wear and tear, a subjective test was evolved. The duplicate study models from the rubber moulds treated with the various coatings were given a code letter then placed in boxes on a side table. Numbered slips were supplied and instructions given, (*a*) to remove the models from their boxes, (*b*) to arrange them in order of aesthetic appeal, (*c*) record the order, and (*d*) return the models to their boxes. The whole operation took about 5 minutes. These models

Fig. 6.—Untreated plaster surface with scoring due to a nylon brush at the top, and a groove cut by a steel scribe at the bottom of the photograph.

Table II.—Results of the Scratch Test

Material	Mean Width of Scratch (inches)
1. Plaster	0·0515
2. Model stone	0·0348
3. Fatty acid	0·0192
4. Vinyl	0·0156
Die stone	0·0136
5. Varnish	0·0100
Acrylic spray	0·0092
Polyurethane spray	0·0076
Acryloid	0·0076

Significant differences occur between the five groups but no significant differences occur within the groups. Differences of 0·0035 are significant at 0·001 level.

were then examined by 100 people, professional staff, technicians, students, and nurses. This handling showed which coatings best stood up to normal wear and tear.

Marks were given in descending order, i.e., 13 for first choice, 12 for second, and so on. It became obvious after a while that the permutations of model materials and coatings were too great and while the selection of models at the top and bottom of the scale was easy, some difficulty was being experienced in producing any order in

the middle of the range. However, three groups emerged classed as being aesthetically acceptable, unacceptable, and the rest (*Table III*). The group of white plaster models with a colourless coating were more popular than the cream or yellow stone models. The discoloration of the models and the uneven finish obtained with varnish and polyurethane made these coatings least acceptable.

Table III.—Aesthetic Appeal of Coatings in Order of Preference

*Group**	*Casting*		*Coating*
1.	Stone	+	Vinyl emulsion
	Plaster	+	Fatty acid
	Plaster	+	Acrylic spray
	Plaster	+	Acryloid
2.	Stone	+	Fatty acid
	Stone		(Uncoated)
	Plaster		(Uncoated)
	Plaster	+	Vinyl emulsion
	Stone	+	Acrylic
3.	Plaster	+	Varnish
	Plaster	+	Polyurethane spray
	Stone	+	Polyurethane spray
	Stone	+	Varnish

*Groups 1, 2, and 3 are referred to in text.

DISCUSSION AND CONCLUSIONS

The impact and transverse strength tests both showed that plaster rods treated with acrylic spray and the Acryloid were significantly stronger than those covered by other materials, and, in fact, approached closely the strength of model stone. The values for model stone and die stone in this series are of the same order as those obtained by Combe and Smith (1964) (*Table I*).

The acrylic in the aerosol dispenser is a dilute type of Acryloid and the specimens treated by dipping were stronger only because this method of coating allowed a greater degree of penetration. Apart from the fatty acid, which while penetrating the specimens completely had no inherent strength, none of the other coatings penetrated more than a few microns.

The test for resistance to abrasion and scratching showed acrylic to be some 43 times harder than untreated plaster but even the fatty-acid treated surface gave 8 times the resistance to scratching and offered some protection. The untreated die stone showed a surface hardness better than the fatty-acid treated surface but this might be somewhat misleading since, as shown by Hosoda and others (1962), when cast against alginate, stones have appreciably softer surfaces (*Table II*).

All the materials protected the plaster from finger marks. There was a definite preference for the clear gloss finish of the vinyl emulsion with fatty acid and acrylic a close second and third (*Table III*). In practice, however, it was found that the vinyl emulsion could be stripped off the models without much difficulty and the rather thick skin tended to obscure surface detail. The blotchy finish produced by the varnish and polyurethane made them aesthetically unacceptable.

The economic factor was considered but none of the coatings cost more than a penny per model. Spraying and dipping were much easier methods of applying the coatings than painting.

White study models with a slight gloss are most pleasing for demonstration purposes. Acryloid coating penetrates the plaster and significantly increases its transverse strength—an important factor where proclined incisors are concerned. (Models cast in plaster and coated with acrylic are nearly as strong and cheaper to produce than the untreated stone models currently favoured by many orthodontists.)

Die stone is significantly harder than model stone or plaster treated with acrylic but it is too expensive, for routine use. However, for special demonstration models which are needed quickly and without the inaccuracies which tend to occur in duplication the use of white die stone treated with acrylic is recommended.

PRACTICAL APPLICATION

Method for producing the Models

1. Cast the impressions and base in plaster and trim.
2. Place in warm dry store (70° F.) to eliminate moisture.
3. Mark appropriate legend (e.g., name, number, and date) on base.
4. Immerse for 10 minutes in 10 per cent solution of Acryloid, then drain and allow to dry.
5. Dip briefly in 20 per cent solution, allow to dry and store.

Acryloid resin dissolves in a number of aromatic hydrocarbons such as tuluol, acetone, and xylol. Tuluol is toxic to the liver. Acetone is less toxic and evaporates quickly thus speeding the drying process, but is highly inflammable and is best used in a fume cupboard. Xylol is the safest solvent but takes longer to evaporate so that models may take 24 hours to dry after the first dip. Acetone and xylol may cause dermatitis so models should be retrieved from the bath by means of a wire clip or tray.

SUMMARY

A number of materials suitable for coating plaster study models were examined to see if any would improve the strength of the plaster and increase its resistance to scratching and abrasion, while at the same time enhancing its appearance. While the latter requirements were easily fulfilled,

only the acrylic coatings significantly improved the strength of the plaster.

The greatest penetration and therefore strength was obtained by dipping the models in an acrylic solution, but the easiest method and the one probably most suited to general practice was the use of the acrylic spray.

Acknowledgement

We are indebted to Mr. Pearson of the Department of Social and Occupational Medicine in the University of Dundee for his assistance in the statistical analysis.

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DISCUSSION

Mr. D. D. Di Biase asked about the cost of the acrylic materials.

Mr. Martin replied that he could not give a direct answer. The acrylic they used was obtained from the industrial chemists who manufactured the product. He had for demonstration purposes a sample of this acrylic and the name and address of the retailers who were prepared to supply small quantities to the dental profession. The cost was not high; he imagined it was about a penny a model.

Dr. J. D. Atherton thought that the paper would lead to a higher standard of study models. He had struggled for years, off and on, to try to raise the standard of study models but it was awfully difficult to keep up a good standard. He had obtained some models from the U.S.A. which were superb but cost about £2 each. They had an absolutely perfect surface and this had puzzled everyone at Liverpool for quite a time. He had found out how they were made. A white stone was used. A stone of the same type could be obtained in this country from British Gypsum. A great variety were manufactured and only one or two of them got to the dental trade. A vacuum was used to remove all the air bubbles and produced a very nice finish indeed.

The authors had given a choice of about three finishes and it would be interesting to know which one they advocated.

Had the authors any particular recommendation for a really nice photograph?

Mr. Martin said that for purely photographic purposes he would recommend ordinary plaster, untreated, because the gloss of the treated model made photography rather more difficult.

With regard to vacuuming the plaster, Combe and Smith had pointed out that there was very little difference between vacuuming and vibrating. In both cases, provided that the mix was reasonably workable, it was satisfactory. With the vibrating method the air-bubbles were removed quite satisfactorily and this could result in a harder model than the old textbook suggestion of a reduced water content giving a stiff mix. This might give a hard surface but it was likely to have air-bubbles in it which gave lines of weakness. A suitable mix thoroughly vibrated gave an equally strong model.

THE RECOGNITION OF BILATERAL CRANIOFACIAL DEFORMITIES

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INTRODUCTION

Asymmetry is a constant feature of the head and face. Mild deviations from the normal or ideal are acceptable and may even be attractive. When, however, these mild deviations exceed certain limits, the features become peculiar, grotesque, repulsive, and finally hideous.

These deformities form a vast number of abnormalities affecting the head and face but in this paper unilateral craniofacial deformities and common clefts of the face will be omitted, only bilateral deformities will be included and these will be limited to those cases attending for treatment at a centre specializing in plastic, ophthalmic, and maxillofacial surgery.

When considering the differential diagnosis of craniofacial deformities, it is essential to recognize certain typical features associated with each

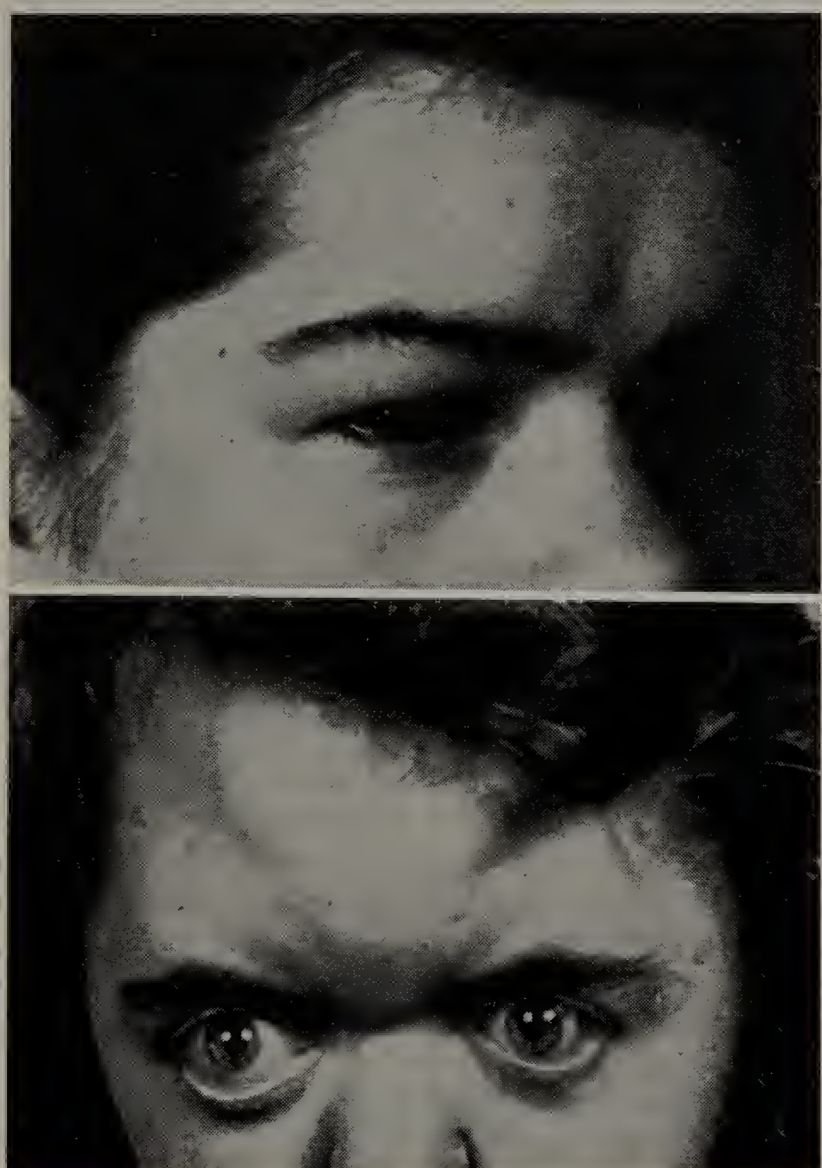

Fig. 1.—The forehead may show diagnostic features. *Top*, The midline depression seen in cleidocranial dysostosis. *Bottom*, The bossing in the midline as seen in cranial synostosis—Apert's type.

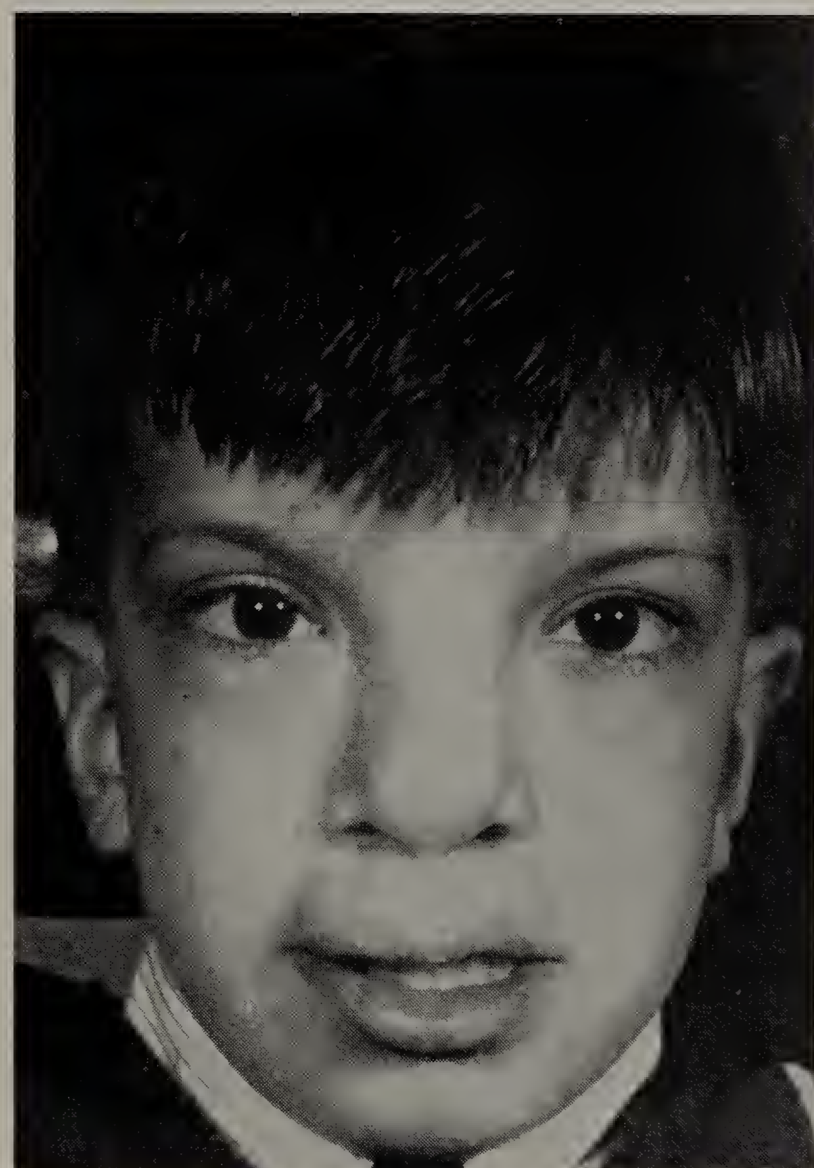

Fig. 2.—Great width between the eyes. Ocular hypertelorism is a common feature of many craniofacial deformities.

Presented at the Country Meeting held on 16 May, 1970.

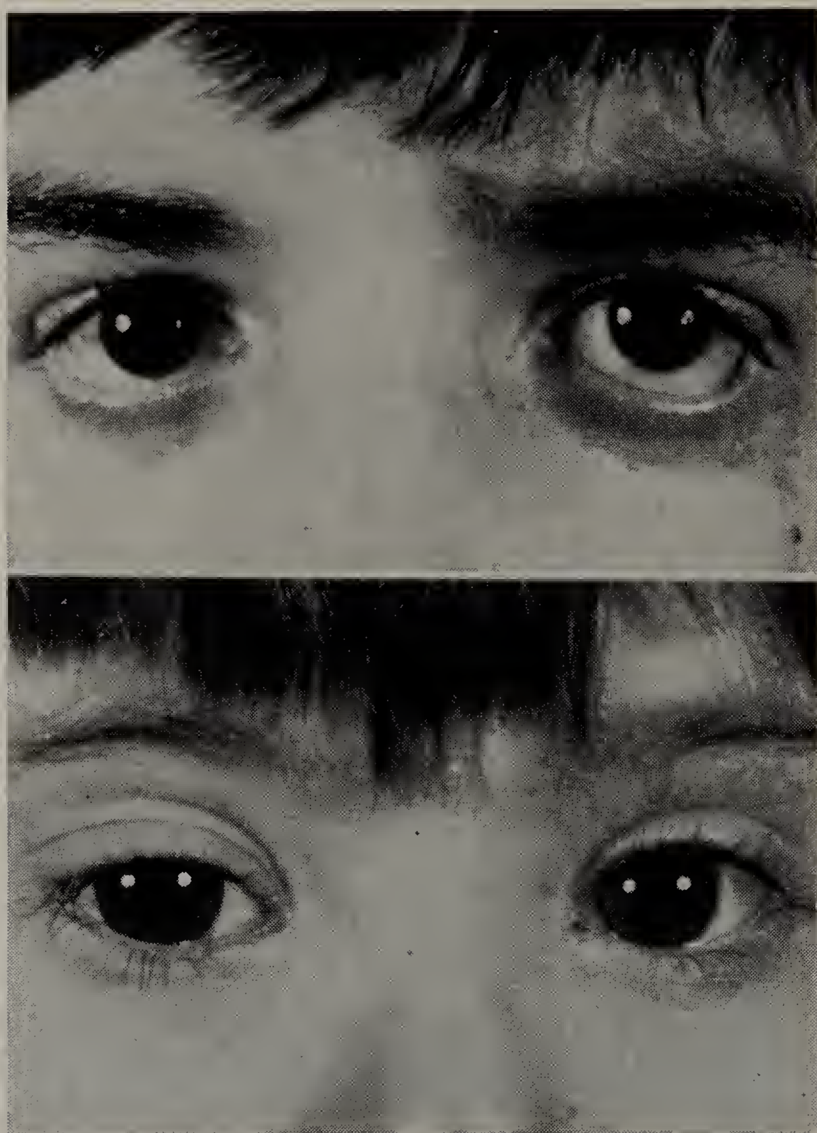

Fig. 3.—The angle of the eyelids. *Top*, In Treacher-Collins syndrome they slope outwards and downwards. *Bottom*, In Down's syndrome they slope outwards and upwards.

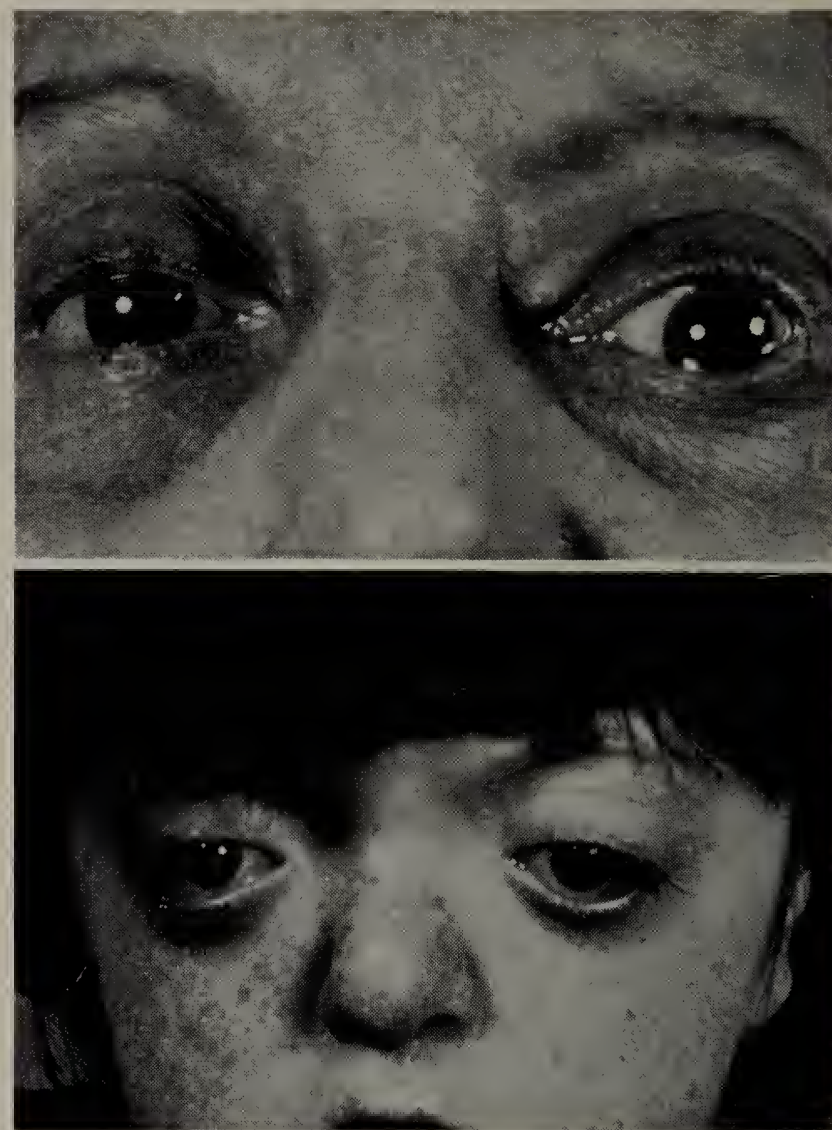

Fig. 4.—*Top*, True exophthalmia; the lids are drawn back showing equal amounts of eye. *Bottom*, Proptosis as seen in acrocephaly; the eyes are pushed from the sockets and are hooded by the upper lids.

syndrome. The head may have an unusual shape or size, the forehead may recede or bulge forward, may show frontal bossing, or a midline depression (*Fig*. 1). The eyes probably reveal more than any other feature; they may be very wide apart (*Fig*. 2), slant upwards and outwards, or downward and outward (*Fig*. 3). They may protrude, the upper and lower lid may show unusual positions (*Fig*. 4), and the lids themselves may show notching or colobomata (*Fig*. 5). The nose may be small with poor nasal respiration suggestive of underdevelopment of the middle third of the face; pseudo-prognathism may be present. Various malocclusions may be present and the teeth may be partially absent, discoloured, or misshapen. Isolated cleft of hard and soft palate is a common feature.

Fig. 5.—A coloboma or notch in the eyelid may be a feature. *Top*, In unilateral first arch syndrome, the coloboma is at the junction of the inner third and outer two-thirds of the upper lid. *Bottom*, In bilateral first arch syndrome, Treacher Collins type, it is at the junction of the inner two-thirds and the outer third of the lower lid.

Some of the above features combined with others unite to give the typical characteristic of each syndrome and knowledge of these is essential in making a differential diagnosis.

PROGNATHISM AND MICROGNATHISM

Prognathism

Prognathism may be defined as an abnormal protrusion of one or both jaws and is probably the most common facial deformity.

Bimaxillary prognathism is rarely seen as a craniofacial deformity but occurs naturally as a racial characteristic and increases in intensity as the primate tree is descended.

Mandibular prognathism may be divided into true and pseudoprognathism, and true prognathism can be further divided into inherited and acquired prognathism. Inherited prognathism may be a family characteristic and is well demonstrated in the Habsburg family (Grabb, 1968).

Powerful mandibles with Class III malocclusions can be a sign of masculinity but in girls can be a distressing and disfiguring affliction. Acquired prognathism is found when there is over-secretion of the pituitary growth hormone occurring after growth has ceased. If this occurs before 21 years of age, gigantism is the result and after 21 years of age, acromegaly ensues.

In gigantism there is an overall increase in the connective tissues of the body, producing enlargement of dimensions within normal proportions. Acromegaly (*Fig.* 6), which is commoner in males than in females, occurs after the bony skeleton has finished growing and is an overgrowth of the connective tissues, particularly at the extremities of the body. The hands and feet become progressively larger, while the lips, nose, and supraorbital area become enlarged and gross giving the face a heavy coarse appearance. The jaws, both upper and lower, may enlarge, the teeth becoming very spaced. This enlargement is often confined to the mandible producing severe prognathism.

Fig. 6.—An acromegalic face, note the coarseness of the features and the increase in size of the mandible.

Pseudoprognathism occurs when a normally well-developed mandible occludes with an agenetic maxilla and is a common feature associated with cranial synostosis and bilateral clefts (*Fig.* 7). The lack of anteroposterior growth of the maxilla produces an anterior cross-bite while the Class III malocclusion is further accentuated by the overclosure of the mandible articulating with a maxilla deficient in vertical height.

Micrognathism

As Pruzansky (1969) points out, small mandibles must be measured in four dimensions, time being an important addition to length, breadth, and height.

Mandibular micrognathism varies considerably in degree and may be associated with certain

craniofacial deformities, or may be in isolation. ' Catch up ' growth forms a convenient way of classifying micromandibles.

The Pierre Robin syndrome has the commonest form of ' catch up ' micromandible, and is associated with isolated cleft palate and glossoptosis. The fact that the growth spurt of the micromandible can in a few years attain normal dimensions is remarkable. Some, however, have a growth spurt but lack potential and end up as small mandibles.

Pierre Robin's syndrome is probably caused by the failure of the cranial base to extend in utero (Negus, 1929; Glass, 1955). Poswillo (1968) considers it to be due to a reduction in amniotic pressure. McKenzie (1958) considers it to be a variant of the first and second arch syndrome. The glossoptosis would appear to be caused by the inability of the mandible to grow and to carry the tongue downwards and forwards from the nasopharynx while the isolated palatal cleft is probably secondary to the glossoptosis, the tongue occupying the nasal cavity at the critical time of palatal closure. This syndrome is also associated with other abnormalities, the eyes being particularly affected (Smith and Stowe, 1961). Opitz (1969) considers there is strong evidence of genetic origin.

Micrognathia

True micrognathia is seen in those cases where the mandible is small from birth and remains small throughout life and may be an inherited pattern, in contrast to inherited prognathism of the Habsburg type.

Other forms of micrognathia are due to growth or developmental abnormalities of the condylar heads of the mandible. This is easily seen where the growing cartilages of the condyles are damaged by infection or trauma, after which growth ceases. In first arch defects where one condyle is absent, micrognathia occurs despite the overgrowth of the sound side.

Fig. 7.—Pseudoprognathism occurs when a well-developed mandible occludes with an underdeveloped maxilla. Before and after surgical reduction of the mandible.

ECTODERMAL DYSPLASIA

This condition (*Fig.* 8) is produced by defective growth and development of the ectodermal tissues and may affect all or only some of the structures of the body. Many different types of ectodermal dysplasia have been described according to the tissues affected (Gorlin and Pindborg, 1964; Redpath and Winter, 1969). The three main abnormalities are:—

1. Shortage of teeth—hypodontia.
2. Shortage of hair—hypotrichosis.
3. Shortage of sweat—hypohidrosis.

Features

The face is smooth and hairless and also lacks colour, while the eyebrows are either absent or poorly developed yet the supraorbital area may be prominent. The eyes appear normal except for reduction of eyelashes but defects of the eye itself

may be present. The lips are full and pouted with a depressed mentalis region, and they may appear dry and cracked. The hair is sparse and woolly in texture while the nails may be poorly developed or even absent. Complete or partial absence of teeth is very common (*Fig.* 9). When teeth are present they show primitive triconodont or peg shapes but have normal enamel, dentine, and cementum. The areas of anodontia give the mouth an edentulous appearance.

Fig. 8.—Ectodermal dysplasia. Note the smooth hairless face with pouting lips.

Aetiology

Gorlin and Pindborg (1964) consider that it is transmitted by an x-linked recessive trait being carried in the male and manifested in the male but they do record its occurrence in the female occasionally.

No ill effects ensue except the inconvenience of absent teeth and peculiar hair, but climate changes may be uncomfortable if the skin of the body is unable to carry out its heat-regulating function.

CLEIDOCRANIAL DYSOSTOSIS

This syndrome is characterized by a disturbance in the calcification of the membrane bones of the clavicle and the skull. Kalliala and Taskinen (1962) have shown that any bone may be affected throughout the skeleton. The face, head, and clavicles, however, do display the main features of the syndrome.

The typical cleidocranial dysostosis patient is easy to recognize but very difficult to describe (*Fig.* 10). The general stature is short and may be broad and thick-set, the drooping shoulders give the appearance of an unusually long neck, the

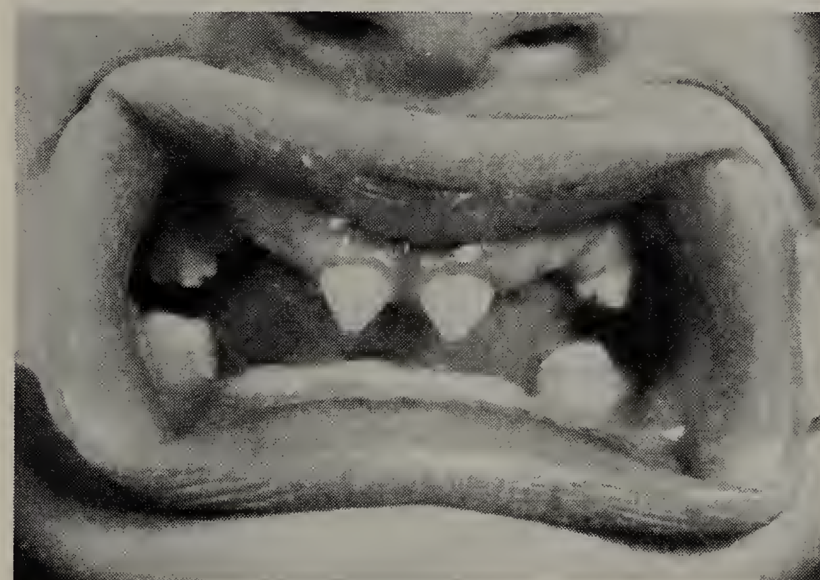

Fig. 9.—In ectodermal dysplasia the teeth may be all or partially absent. Those present are often misshapen.

head appears brachycephalic while the face is small yet the features are heavy.

The broad but short head shows bossing in the frontal area above the eyes and the metopic suture shows a vertical depression between the lateral bulges; this is the reverse of the bulging seen in Apert's syndrome. The cranial sutures are very late in closing and the fontanelles remain open into adult life.

Although there may be a mild exophthalmia, this is masked by the heavy supraorbital ridges associated with the frontal bossing and the nasion area appears flat. Ocular hypertelorism, however, is not seen. The nose is small, thick, and elevated and shows the typical features of an underdeveloped maxilla.

The jaws are well developed although the maxillary arch is often smaller than the normal mandible. The alveolar areas are thick and the mucous membrane is red and fleshy. The main dental feature is the delayed eruption of all teeth in both jaws. The deciduous teeth are retained well into adult life despite the presence of unerupted permanent teeth, which themselves may never erupt and may develop cystic complications. Supernumerary teeth are often present, sometimes in large numbers. Why these teeth fail to erupt is unknown and a solution to this problem might help to solve the mystery of how and why normal teeth erupt. Rushton (1937) found that these teeth were deficient in a layer of

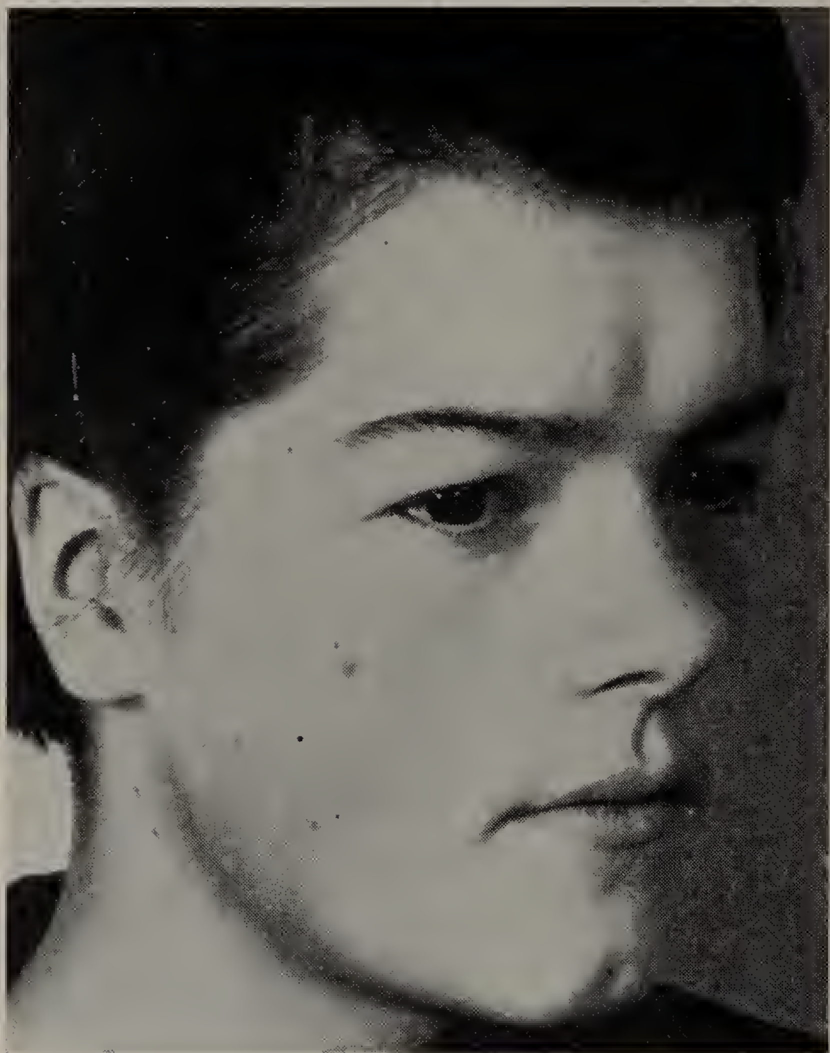

Fig. 10.—Cleidocranial dysostosis produces this typical face with a depression in the mid-frontal area, heavy supraorbital ridges, and agenesis of the middle third of the face.

Fig. 11.—The absence of the clavicles permits approximation of the shoulders in cleidocranial dysostosis.

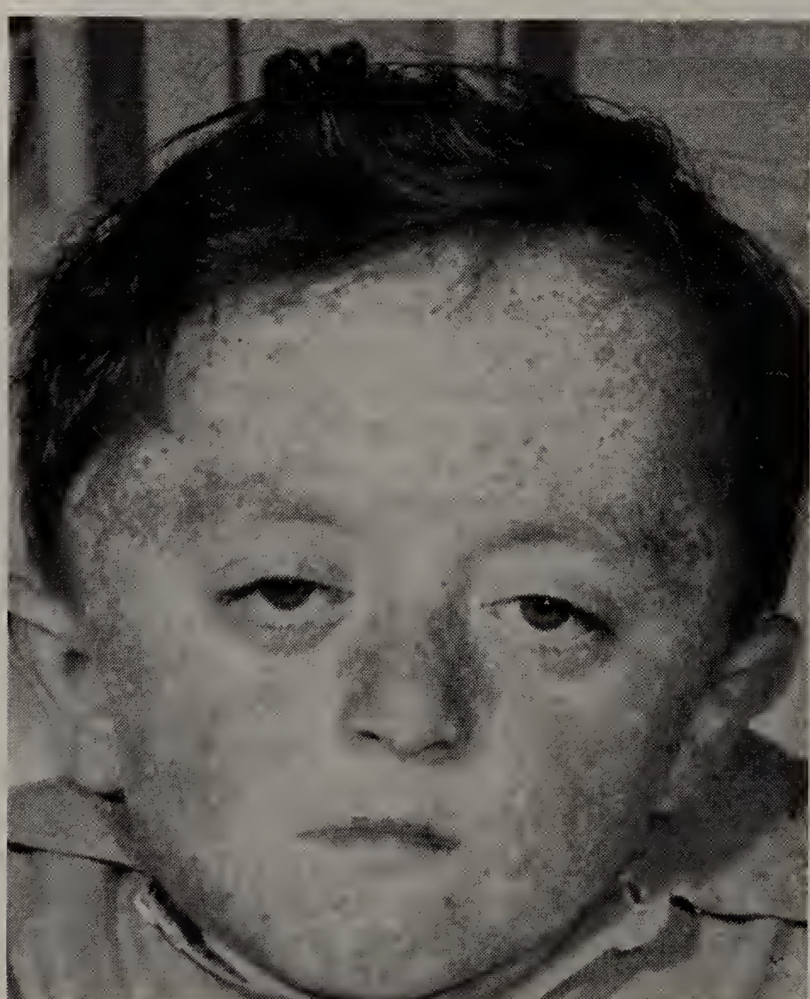

Fig. 12.—In oesteogenesis imperfecta the head may be distorted. This head is very wide and very short from front to back; the cephalic index is 101.

cementum and considers that failure to erupt is due to inability to absorb the bony crypts. This is not borne out in practice where the unerupted teeth have been surgically exposed and subjected to fixed appliance orthodontic treatment to assist eruption.

No tooth movement was achieved and failure was constant.

The clavicles may be partially or completely absent which accounts for the long neck and drooping shoulders and permits a remarkable range of movement of the shoulders (*Fig.* 11); these may be brought forward in front of the chest to contact each other. The absence of the clavicle seems to have no effect on the function, despite the disorganization of the various muscles, such as sternomastoid, trapezius, etc.

Aetiology

This is unknown. Gorlin and Pindborg (1964) consider that half the cases arise spontaneously, the other half are transmitted on an autosomal dominant basis.

OSTEOGENESIS IMPERFECTA (FRAGILITAS OSSIUM)

This is a mesodermal defect affecting the calcified tissues of the body. The shape of the head varies considerably and is probably due to the

postural moulding of the poorly calcified bones caused by the weight of cerebral contents.

Fig. 12 shows the head to be brachycephalic with a cephalic index of 101 (normal is 75–83). The head is broad and also short from front to back, probably due to the moulding of the head as this boy spent most of his life lying on his back. Unlike cleidocranial dysostosis, the skull itself may be thin.

The most obvious diagnostic feature is the blueness of the sclera and is usually the first indication of the defect. This is caused by an undue thinness of the sclera which permits the choroid to show through the white part of the eye.

All bones in these patients are defectively calcified and fractures occur when subjected to the slightest stress. This is especially true when teeth have to be extracted. The removal of teeth must be done with particular care as a fractured mandible is a common feature of these cases. In some cases the long bones cannot bear the weight of the body and become bowed and deformed.

The teeth present typical features of defective mesodermal development; the dentine is severely affected. The colour is an obvious feature. Tooth colour ranges from pink to dark brown with bluish tints, while mixtures of all intermediate colours may occur. They also appear to be very shiny and translucent. The teeth may be reduced in size, while the roots are definitely small with poorly developed pulp chambers.

Odontogenesis imperfecta is probably a closely associated condition affecting teeth only. The cause is unknown but is strongly genetic.

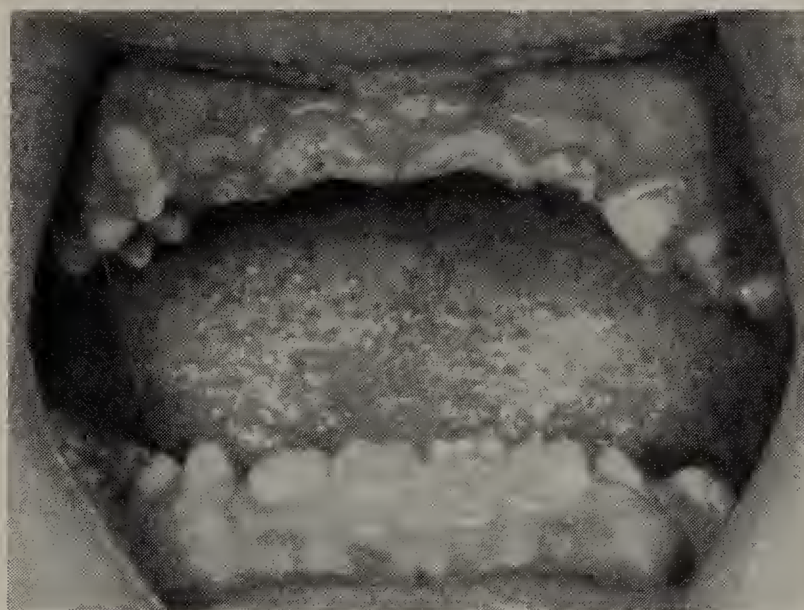

Fig. 13.—In osteogenesis imperfecta, the teeth are usually severely affected; they are poorly calcified and colour ranges from brown to blue.

Fig. 14.—Treacher-Collins syndrome is the true ' bird face ' deformity; note the enlarged maxillary complex and the downward and outward slope of the eyes.

THE FIRST ARCH SYNDROME

The first arch syndrome has been used to describe facial deformities affecting the tissues made up from the first brachial arch, despite the fact that the second and even the third arch may be slightly involved. This descriptive name of first arch syndrome, although not always strictly accurate, is now in common usage. These deformities are either bilateral or unilateral. The bilateral is mandibular facial dysostosis or Treacher-Collins syndrome; the unilateral has many descriptive names including auriculo-mandibular hypoplasia, unilateral facial agenesis, and hemifacial microsomia (Glass, 1966). These two conditions may show similar isolated features but are two entirely separate conditions.

Treacher-Collins syndrome (*Fig.* 14) was first described by Berry in 1889, but Treacher-Collins has given his name to the condition after his description in 1900. This syndrome is easily recognized by the fact that this is the true ‘ bird face ’ deformity; the defects are symmetrical bilaterally. The head may be normal in shape or may have a receding frontal bone. The face shows many typical features, the eyes slope downwards and outwards giving an antimongoloid appearance (*see Fig.* 3). The lower lid often shows a notch or coloboma at the junction of the outer third and inner two-thirds (Berry, 1889) unlike the unilateral first arch defect in which the coloboma is in the upper lid at the junction of the outer two-thirds and the inner third (*see Fig.* 5). There is ocular hypertelorism with no bony depression in the nasion area. The lower border of the orbit is affected by the partial or complete absence of the malar bone and the skin below the outer canthus of the eye is depressed and pigmented.

The ears may be absent or just a crumpled mass of cartilage. There may be accessory auricles along the orotragal line. The auditory meatus may be atresic or completely absent. Incus and malleus are usually absent and deafness is a serious affliction.

The maxilla is usually well developed but may be reduced in size and cause severe dental crowding. Isolated cleft of the hard and soft palate is a common feature. The mandible is a characteristic shape, the ramus is short with a high gonial angle and the pregonial notch may be deep. The dental occlusion varies considerably from case to case but an anterior open bite is not uncommonly seen. The micrognathia combined with the aquiline nose and receding forehead, produce the ‘ bird face ’ effect. There is a strong inherited pattern.

SKULL SHAPES

Skull shapes must obviously be of importance to all orthodontists and as we examine our patients and their dental abnormalities we must automatically associate malocclusion with the supporting structures, that is, the whole head and face. Skull shapes vary considerably in different races and are conveniently classified according to the cephalic index. Long head—dolicocephalic index, below 75; broad head—brachycephalic index, above 83; normal head—orthocephalic, 75 to 83.

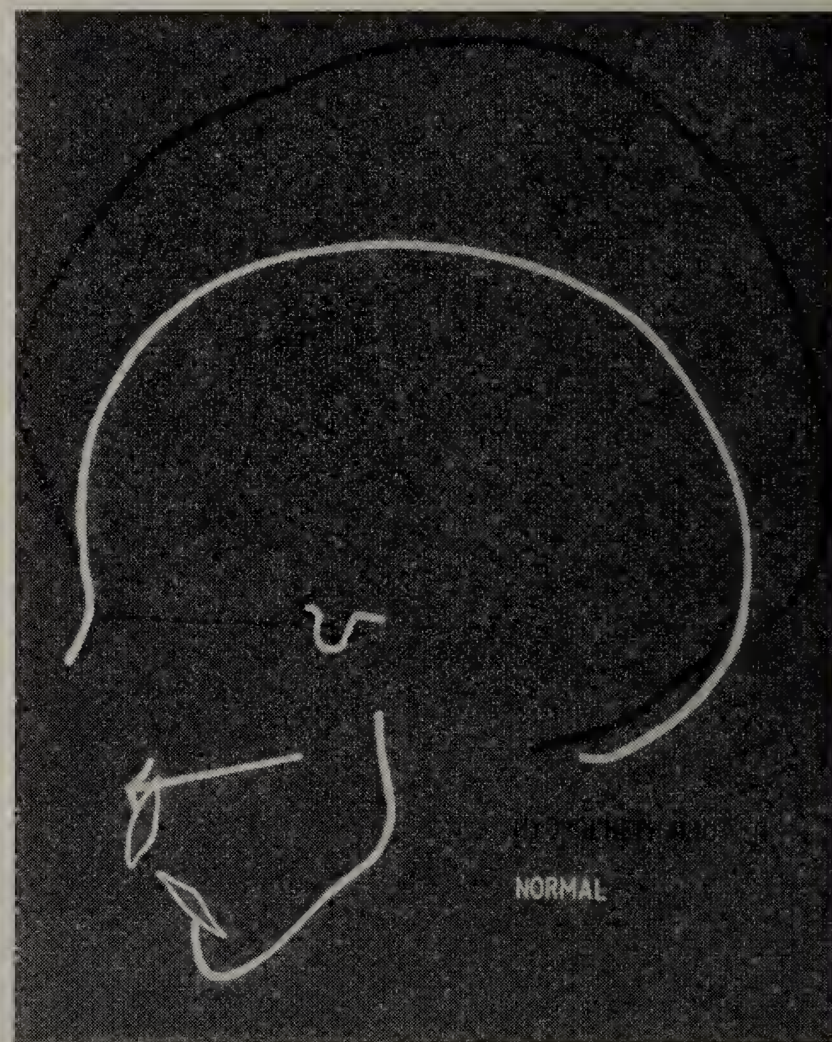

Fig. 15.—In hydrocephaly the skull may be much larger than normal; these skull tracings show the normal and the hydrocephalic skull.

Apart from racial trends and genetic variations, unusual head shapes may be a visible sign of other abnormalities. Cavities such as the cranium and the orbit depend for their size on the soft-tissue contents without which there is no stimulus to grow. It therefore follows that if the brain is very small, the head will be microcephalic, similarly a very large brain will produce a large head; the bony surrounds to the brain remain in a constant state of equilibrium with the contents and change in this equilibrium produces an immediate compensating reaction. This occurs in hydrocephaly (*Fig.* 15). In this condition there is a fault in the circulatory system of the cerebrospinal fluid which raises the intracranial pressure, the skull grows rapidly until a new equilibrium has been established. It is interesting to note that this does not necessarily produce thinning of the skull, nor does it produce the cranial lacunae seen in some cases of synostosis claimed to be caused by raised intracranial pressure.

Premature closure of part or all of the cranial sutures will produce severe deformities of the head shape. The brain grows rapidly during the first year of life and by 4 years of age has achieved 85 per cent of its growth. It is therefore obvious that the earlier the sutural synostosis occurs, the greater the resultant deformity; synostosis occurring after 5 years of age will produce much less deformity than that occurring soon after birth. Skull growth occurs at right angles to the line of the suture, thus different suture synostosis produces different skull shapes (*Fig.* 16).

Lambdoid and coronal suture synostosis is probably the commonest type producing a very wide head which may also be short from front to back. The top of the head is usually raised up to give the arrowhead or acrocephalic shape. Sagittal suture synostosis produces a very long head with little lateral width; this is known as scaphocephaly or keel-shaped. It is not a common synostosis and does not produce any great facial deformities. Synostosis of all or most of the cranial sutures produces the tower-shaped head, turricephaly, seen in Apert's syndrome which is associated with syndactyly. Schurr (1957) maintains that suture synostosis occurs more commonly in males than in females in the ratio of 5: 1. This is not true of Apert's syndrome.

Radiographic evidence of an open suture can be misleading. Post-mortem examination of one skull showed that the sutures which were radiographically open proved at autopsy to have a solid outer place of bone uniting the adjoining bones.

The commonest craniofacial deformity associated with synostosis of one or more sutures is acrocephaly with or without syndactyly. These deformities include Crouzon's and Apert's syndrome but considerable confusion exists between them as the features of both syndromes overlap. Further complication arises from the fact that Crouzon's syndrome is called ' acrocephaly ' while Apert's syndrome is called ' acrocephaly with syndactyly ', despite the fact that the skull in Apert's syndrome is usually tower-shaped and not arrow-shaped.

In Crouzon's syndrome the coronal and lambdoid sutures are synostosed producing severe brachycephaly with a high pointed top to the head; there is no syndactyly. In Apert's syndrome (*Fig.* 17), all or most of the cranial sutures are absent soon after birth. This produces a tower-shaped head, the hands and feet are syndactylous. As both syndromes show similar secondary deformities only Apert's, the severer of the two, will be described (Apert, 1906; Glass, 1958).

The head is broad and high, there is no bulge to the back of the head, while the frontal bone slopes upwards and forwards so that the front and back of the head are parallel producing a tower shape, turricephaly. All or most of the sutures are synostosed soon after birth, the bones of the skull are very thin and may show craniolacunae or ' copper beaten ' markings in the X-rays. This has led to the erroneous conclusion that these skulls all have raised intracranial pressure. Williams (1957), however, has shown that this is not necessarily so and that these lacunae are not related to the cerebral sulci or gyri and are a common feature in some normal skull X-rays.

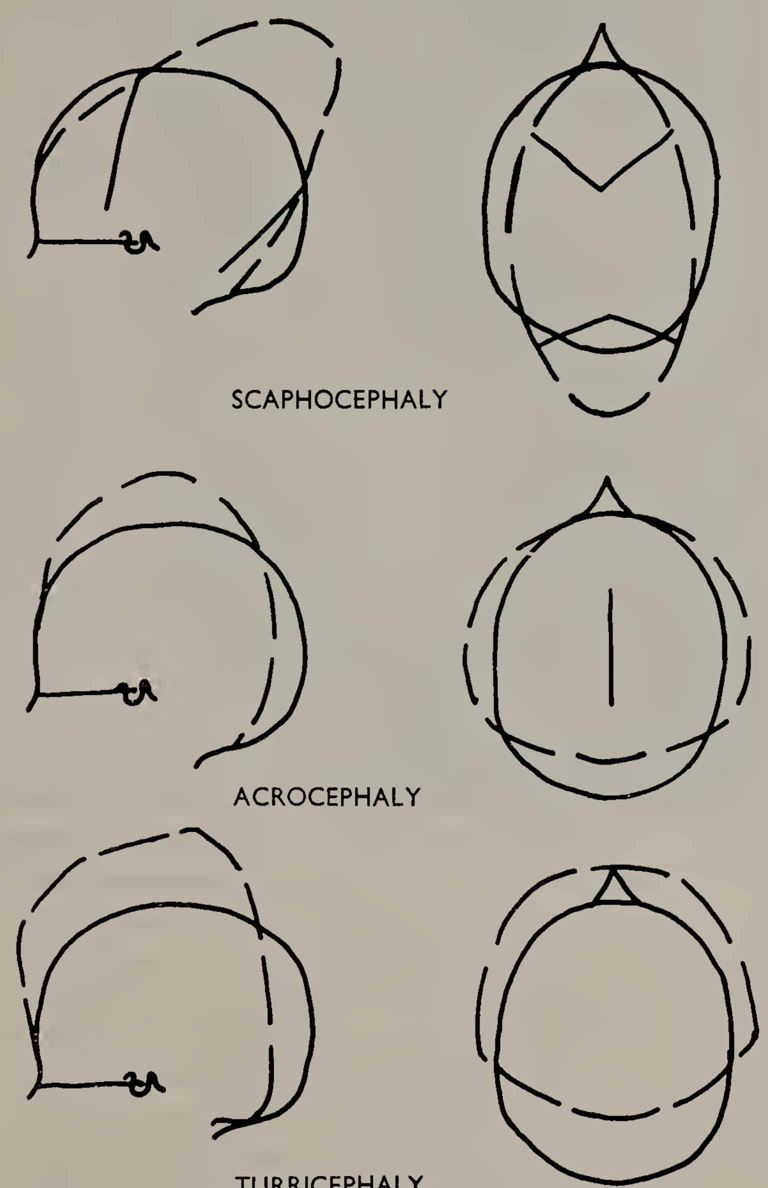

Fig. 16.—Synostosis of the cranial sutures produces different head shapes. *Top*, Scaphocephaly is due to the absence of the sagittal suture. *Centre*, Acrocephaly is due to the absence of the lambdoid and coronal sutures. *Bottom*, Turricephaly with the absence of all cranial sutures in Apert's syndrome.

The cranial base is short in anteroposterior length but the middle fossa is enlarged and displaced forward, the distance from the back of the orbit to the nasion may be 1 cm. less than normal (*Fig.* 18).

The main feature of the face is the underdevelopment of the middle third, which is accentuated by its position between the overhanging forehead and the pseudoprognathic mandible. The forehead, apart from leaning forward, has a large bulge running upwards from the nasion over the area of the metopic suture, in contrast with cleidocranial dysostosis (*see Fig.* 1).

Fig. 17.—The head in Apert's syndrome; note the lack of growth of the middle third of the face with proptosis and pseudoprognathism.

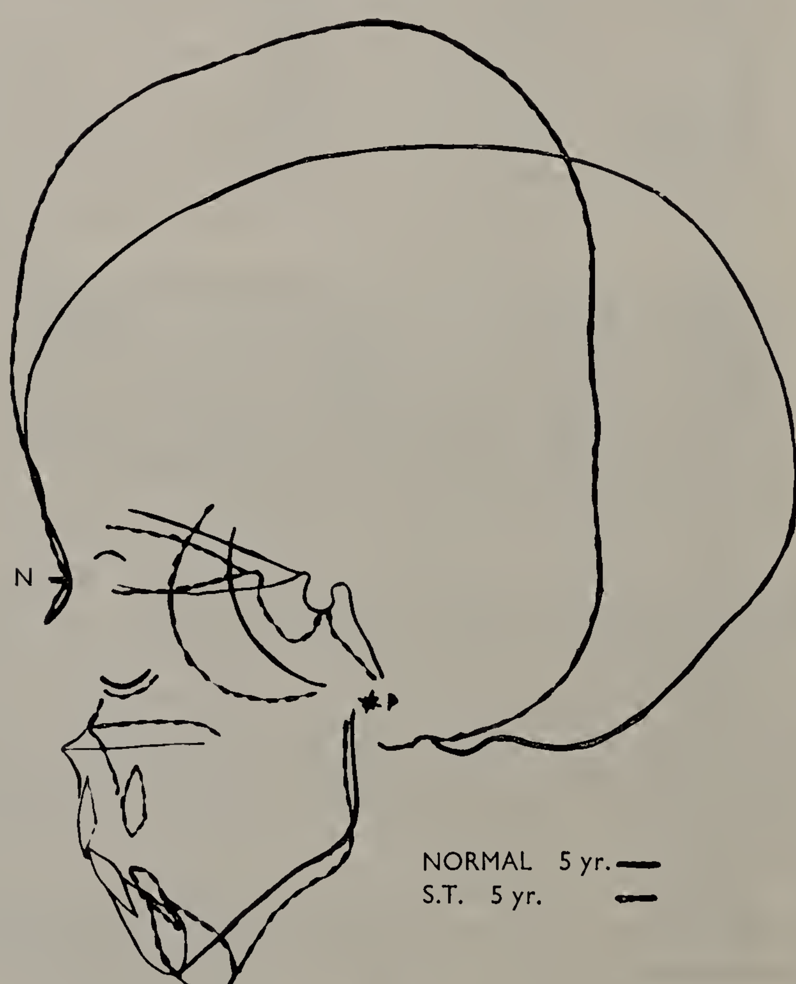

Fig. 18.—Lateral tracing of a normal and a turricephalic skull, 4-year-old Apert's type. Note there are no cranial sutures present, the frontal and occipital bones are parallel, and the middle fossa of the cranial base is displaced forwards.

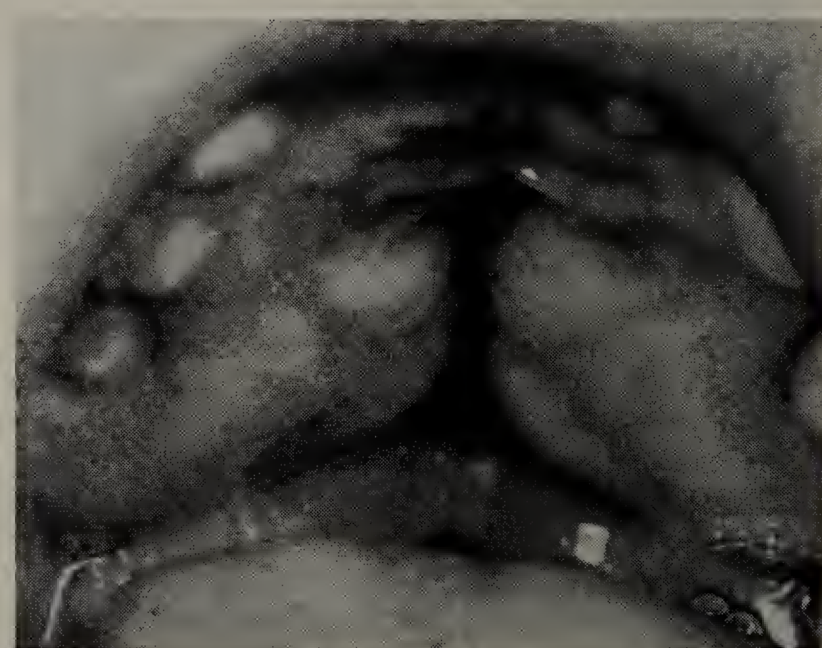

Fig. 19.—Pseudo-cleft palate is often seen in Apert's syndrome due to bulging medially of the sides of the hard palate. True cleft of palate is rarely seen in this syndrome.

The eyes show ocular hypertelorism while the palpebral fissures slant down and out in contrast to Down's syndrome (*see Fig*. 3). The eyes bulge from the sockets and are held in by the hooded upper lids. This is proptosis as distinct from exophthalmos in which the eyes protrude evenly between upper and lower lids (*see Fig*. 4). This proptosis is caused by the shallowness of the back

of the orbits and by the lack of forward growth of the infraorbital part of the maxilla. Strabismus may be present due to the excessive width of the eyes affecting binocular vision and optic atrophy is common.

The nose is short and stubby with poor function and greatly reduced air-way.

The teeth themselves are normal, but lack of maxillary growth produces severe crowding and an open bite. The upper arch is horseshoe-shaped and the palate, although high, is not usually cleft, but the mucoperiosteal bulges at the side of the palate, meeting in the midline, produce pseudo-cleft of palate (*Fig*. 19). The mandible is normal, but articulating as it does with an agenetic maxilla, gives the appearance of prognathism.

The hands and feet show syndactyly with a remarkable symmetry of fused digits of right and left side. The mentality is retarded.

Blank (1960), in his genetic survey of Apert's syndrome, found that there was a constant paternal age effect contributable to a raised paternal age, and that Apert's syndrome is of genetic origin due to a random mutation affecting the germ cells of the aged father. This genetic defect appears to affect a horizon of growth at about the fourth week of intra-uterine life and may affect many parts of the body besides the hands, feet, and head. No recovery is possible and a gradual premature ageing continues throughout life.

GENETIC ABNORMALITIES

In 1956, Tjioth and Levana proved that man carried 46 chromosomes and not 48. Since then rapid advances have been made in the analysis of these chromosomes and in the location of genes. These researches have led to the discovery that chromosomal or gene faults can be demonstrated in certain genetic diseases or abnormalities.

The incidence of genetic abnormalities in Britain is 5 per 1000 live births whereas the incidence of congenital abnormalities is 15 per 1000 (Carter, 1963) so the former cannot be considered common. Genetic abnormalities are divided into two main groups. Chromosomal defects affect many parts of the body at various horizons of development, such as Down's and Turner's syndrome, and gene point defects, localized at a specific place on the chromosome and affecting some isolated system, achondroplasia being a typical example.

Down's syndrome of all the genetic disorders is probably the most important to this profession. This syndrome has many names including ' Mongolism ', ' G Trisomy ', ' Trisomy 21 ', and as the latter name suggests, chromosome 21 shows an extra chromosome attached to the pair; this is a constant finding in all Trisomy 21 cases. Selective Trisomy 21 has been demonstrated in which only the cells of certain tissues show this chromosomal abnormality and the symptoms are confined to those specific tissues. This confirms the contention of Speitzer (1957), who maintains that this syndrome is a developmental abnormality of ectodermal origin affecting skin, hair, teeth, and brain.

Most cases of Trisomy 21 are the result of non-disjunction of the chromosome and is closely associated with a high maternal age, a small number of cases occur from young mothers and are probably due to chromosomal translocation.

Penrose (1961) considers the incidence of Trisomy 21 to be 1 to 2 per 1000. Gorlin and Pindborg (1964) maintain that they account for 10 per cent of all institutional inmates. The important factor is the increased incidence with the higher maternal age. Penrose cites the incidence 1 in 2300 for mothers under 20 years and 1 in 46 for mothers over 45 years and maintains that the main increase occurs when the maternal age is over 30 years.

The main features are mental retardation and short powerful stature with a small, round, brachycephalic head. The face is very typical and very obvious at birth, the features are heavy and coarse with the eyes wide apart slanting outwards and upwards, the reverse of Treacher-Collins syndrome (*see Fig*. 3). The ears and nose are small and the middle third of the face is underdeveloped. The mouth is small with a large fissured tongue which may protrude through the lips; speech may be slurred. The teeth are well calcified and usually caries free, but may be conical in shape. The hands are always short and broad with short stubby fingers, the little finger may be half the normal length.

The fact that certain deformities are directly associated with gene or chromosome structural abnormalities has opened up interesting fields of preventive research. It has been found that at 22 weeks the amniotic fluid contains cells of the foetus and that these cells can be withdrawn and cultured to show the chromosomal picture of that foetus. If this shows an extra chromosome attached to the twenty-first pair then Down's syndrome can be definitely diagnosed and a termination of the pregnancy can be advised.

Further interesting studies by Nelson and Emery (1970) using amniocentesis have shown that the sex of the foetus can be determined to an accuracy of 87 per cent and that this could be of importance in sex-linked abnormalities, such as haemophilia, where the mother is the carrier and her male children will show manifestations of the disease.

CONCLUSION

Craniofacial deformities present tremendous national and family problems and everything

possible must be done to prevent these tragedies. Genetic counselling has now become an important factor in the avoidance of deformities. Men and women who may carry a mental or physical defect can now obtain advice on the chances of transmitting this defect to their children. The younger generations are becoming much more aware of the burden imposed upon a family by unwanted or deformed children. They have now learned to control family quantity and will soon want to control quality.

Acknowledgements

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THE EFFICACY OF DENTAL WELDING MACHINES

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Nearly 100 years ago, in 1877, Elihu Thompson attempted to join two metals by passing an electric current through them, and in 1886 took out the first patent for electric welding, or butt welding as we know it today. It was not until the late twenties, however, that orthodontists began to recognize the possibilities of resistance welding techniques. This interest was precipitated by the transition from the use of platinized gold to that of stainless steel for orthodontic appliances.

Resistance welding appears to have been introduced to dentistry by Charlier (1928) and De Coster (1931) and soon the advantages and disadvantages over soldering were being discussed. Bell (1932) described both a direct current machine using heavy storage batteries and a transformer-type welder operated from the mains supply. About the same time Sheldon Friel was demonstrating resistance welding in Dublin and he discussed the subject at a meeting of the British Society for the Study of Orthodontics in 1933. Early work on resistance welding applications and welder design for orthodontic use was done in the thirties and forties by Friel (1933), Watkin (1933), Friel and McKeag (1939), and Parfitt and Friel (1946).

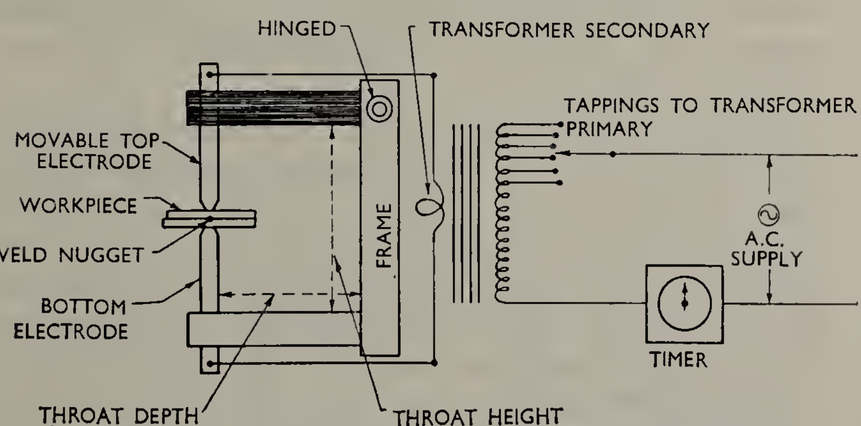

Fig. 1.—Diagram of a basic spot welding machine.

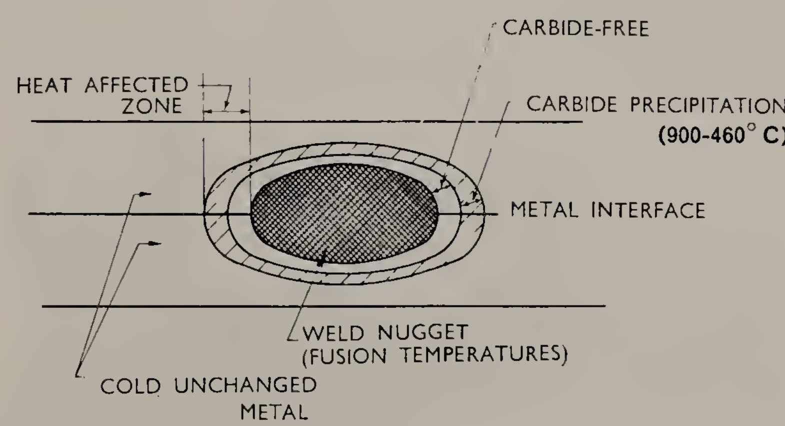

Fig. 2.—Diagram of a spot weld in 18/8 stainless steel.

PRINCIPLES OF RESISTANCE SPOT WELDING

The blacksmith heats the metal to the plastic state and applies the welding pressure by the strokes of his hammer. Resistance welding employs the same basic principles to produce this end-result but replaces the forge fire and the blacksmith's hammer by the heating effect of an electric current and mechanical methods of applying pressure (*Fig.* 1). Pressure is applied by the electrodes to the work by an arrangement of levers or springs, and then a current of high amperage and low voltage is passed for a fixed time interval. This pressure squeezes out the oxide film, commonly accepted as being a thin film of chromium oxide (American Welding Society, 1963), and allows crystal growth across the parts to be joined. It is prolonged after the current has been cut off to forge the weld and hold it together while it cools.

Fig. 2 represents a spot weld in 18/8 stainless-steel strip. The central area represents the fused metal or weld nugget. Adjacent areas show the heat-affected zone and beyond these is the cold, unchanged metal. The heat developed in the weld area is expressed by the relation:—

$$H = I^2RTK$$

where, I^2 is the square of the welding current, T is the time of application of the current,

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Presented at the meeting held on 9 March, 1970.

R is the electrical resistance at the point of welding, and K is a factor representing heat loss by conduction, convection, and radiation.

1. The welding current is a squared quantity and, as it is proportional to the heat produced, is a critical parameter requiring a precise means of control.

2. Welding times in orthodontics should be very short, of the order of 10 milliseconds or less.

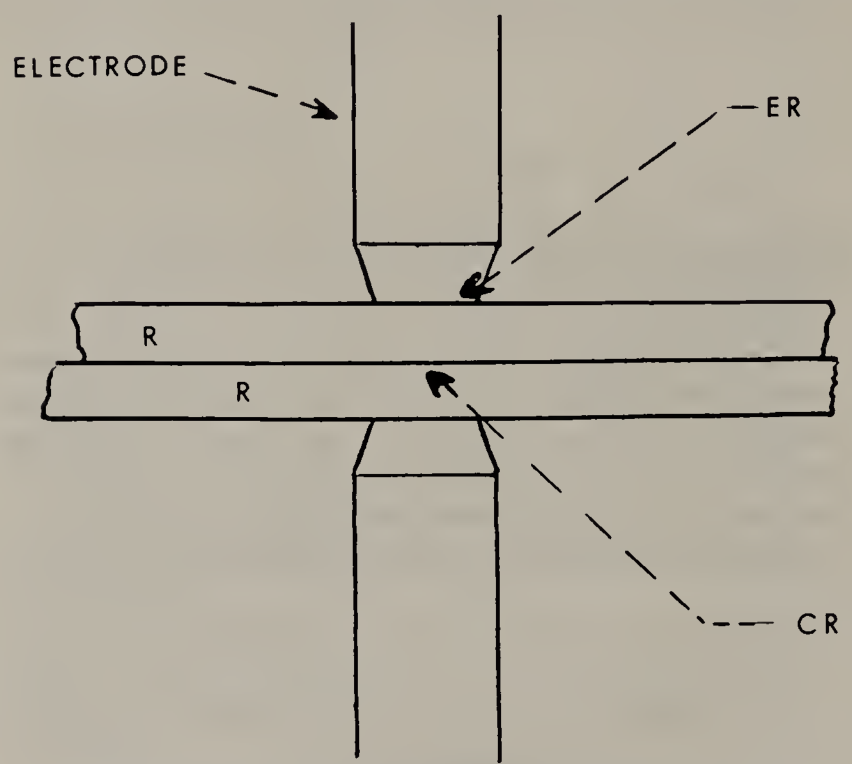


Fig. 3.—Resistances across the electrodes where R is the resistance of the metal; ER and CR are the resistances at the interfaces of the electrode and the metal to be welded, and the two pieces of metal respectively.

The time factor is perhaps even more critical than that of the current. When the welding time is too short there will be a weak weld or no weld at all because the temperature rise will not be sufficient to cause fusion of the metal. On the other hand, if it is over-prolonged there may be pitting and scorching of the work with over-extension of the heat affected zone and even expulsion of the weld metal. When all other factors are constant, the weld nugget will increase in size with increase in time until a certain maximum diameter is reached. Beyond this point an increase in welding time will not increase the diameter of the weld (Parfitt and Friel, 1946).

Although chromium carbide precipitation, which predisposes to weld decay, should be considered in the context of welding time (Keating, 1955), we do not regard it as a real issue in orthodontics today. Only under conditions of severe chemical attack do the effects of ' weld decay ' become apparent (Gill and Simons, 1950). It is important, however, to recognize that heating a metal brings about a change in its structure dependent upon the temperature attained, the time of application of this temperature, and the composition of the metal. The cooling rate also influences the resulting weld structure. Rapid cooling, in effect, quenches the metal. A long welding time will reduce the rate of cooling, extend the heat affected zone, and reduce the hardness of the metal. On the other hand, short welding times will increase the rate of cooling, reduce the extent of the heat affected zone, and increase the hardness of the weld metal. The absence of any discoloration will indicate that the hardness of the metal has not been destroyed by over-prolonged heating.

3. The total resistance (*Fig.* 3) is made up of the resistance (R) of the metal itself, the contact resistance (ER) between the electrode tips and the metal to be welded and, most important, the contact resistance (CR) at the junction of the two parts to be joined. The heat generated at this point raises the temperature of the small contact area to cause fusion of the metal.

The contact resistance between the electrodes is related to the electrode pressure and is approximately inversely proportional to it. If we increase the pressure we reduce the resistance across the parts to be joined and so reduce the heat produced in the weld. Reducing the pressure will increase the contact resistance at the welding point and, within limits, increase the heat produced in the weld.

Pressure is also bound up with the area of the electrode tip. Any variation in the electrode tip size will affect the current density, the pressure per unit area, and the contact resistance at the point of welding. If the pressure at the electrode tip is too low, due to too large a tip diameter, the contact resistance between the electrode tip and the work will be too high and this, together with the decreased current density, will result in porous and weak welds. On the other hand if the area of the electrode tip is too small not only will the result be a weaker weld, but indentation of the work may become excessive due to the localized surface pressure.

The British Welding Research Association (1953) recommend that the electrode pressure for 18/8 stainless-steel strip should be at least 15,000 lb. per square inch and, ideally (1967) 30,000 lb. per square inch. However, in orthodontics the stainless-steel tape and wire to be welded is narrow in width and of such fine gauge that good apposition of the material is obtained with much less pressure.

The resistance offered to an electric current is inversely proportional to the cross-sectional area and directly proportional to the length of the conductor. Electrodes, in theory, should be short and bulky and have low electrical resistance for the efficient conduction of current to the welding point, and also to allow heat to be carried rapidly away (Adams, 1957). Rapid removal of heat from the welding area will reduce any tendency for the electrodes to fuse to the work. In practice, however, bulkiness may have to be

sacrificed for accessibility, especially where the welding of small brackets is concerned.

Hard, drawn, electrolytic copper is not suitable for welding the 18/8 stainless steels as it softens and easily deforms when heated. Various copper alloys such as Mallory 3, a copper-chromium alloy, possess the right hardness. The British Welding Research Association (1967) advise the use of copper-beryllium electrodes for welding the 18/8 stainless steels.

SPOT WELDING MACHINES

The function of a spot welding machine is to provide a means of controlling the factors of pressure, welding current, and their time of application. The operator should only have to be concerned with the pre-setting of the controls and the positioning of the work between the electrodes.

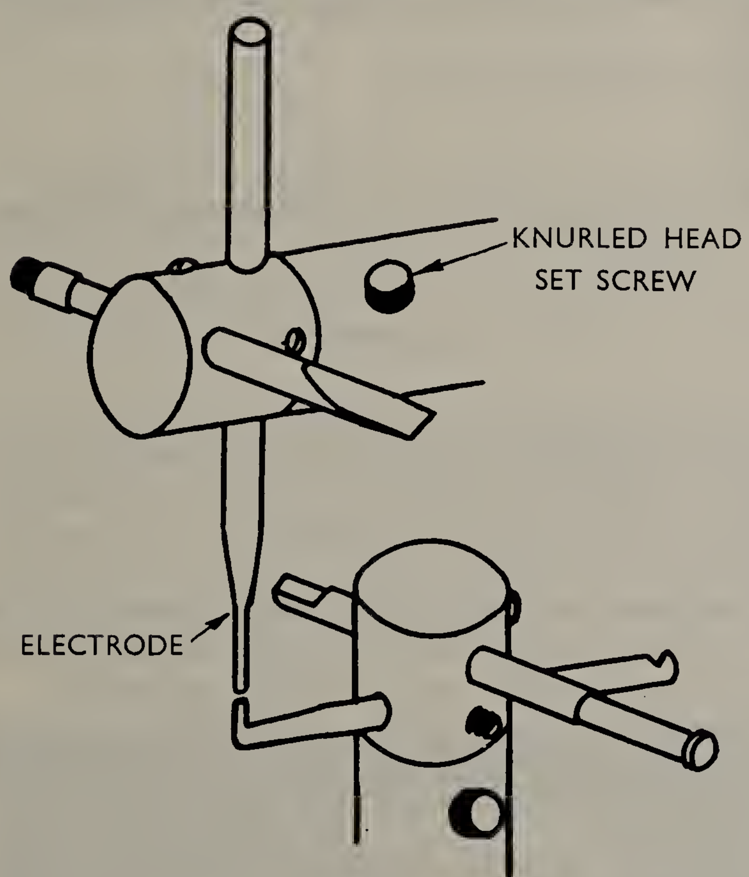


Fig. 4.—Upper and lower fourway turrets which rotate full circle.

Spot welding machines (*Fig.* 1) consist essentially of (1) a transformer, (2) an electrode pressure adjustment, (3) a current switch, and (4) a time control.

1. Regulation of the current is carried out by a number of tappings on the primary side of the transformer.

2. The electrode system must be resilient and possess little inertia so that the movable arm is immediately able to follow up any movement at the welding point due to reduction in thickness of the metal. This may be caused by indentation due to the applied welding pressure, the formation of a fillet, or by expulsion of the metal. In some dental welding machines the electrode pressure adjustment uses a pivoted upper arm which descends to bring the electrode faces into contact. This is shown with a hinged joint in *Fig.* 1. A trip switch included in the pressure mechanism initiates the welding current when the required pressure is reached. Most welders of the portable type use a spring-loaded lower arm.

3. Usually, the switching by mechanical contactors or electronic devices is such that once the controls have been pre-set the operator cannot influence the welding cycle. We did examine one welder, however, in which a simple toggle switch was used to make and break the electrical circuit. Welding was then dependent on the speed of movement of the switch by the operator who, consciously or otherwise, could vary the time of current flow and so effect the energy input into the weld.

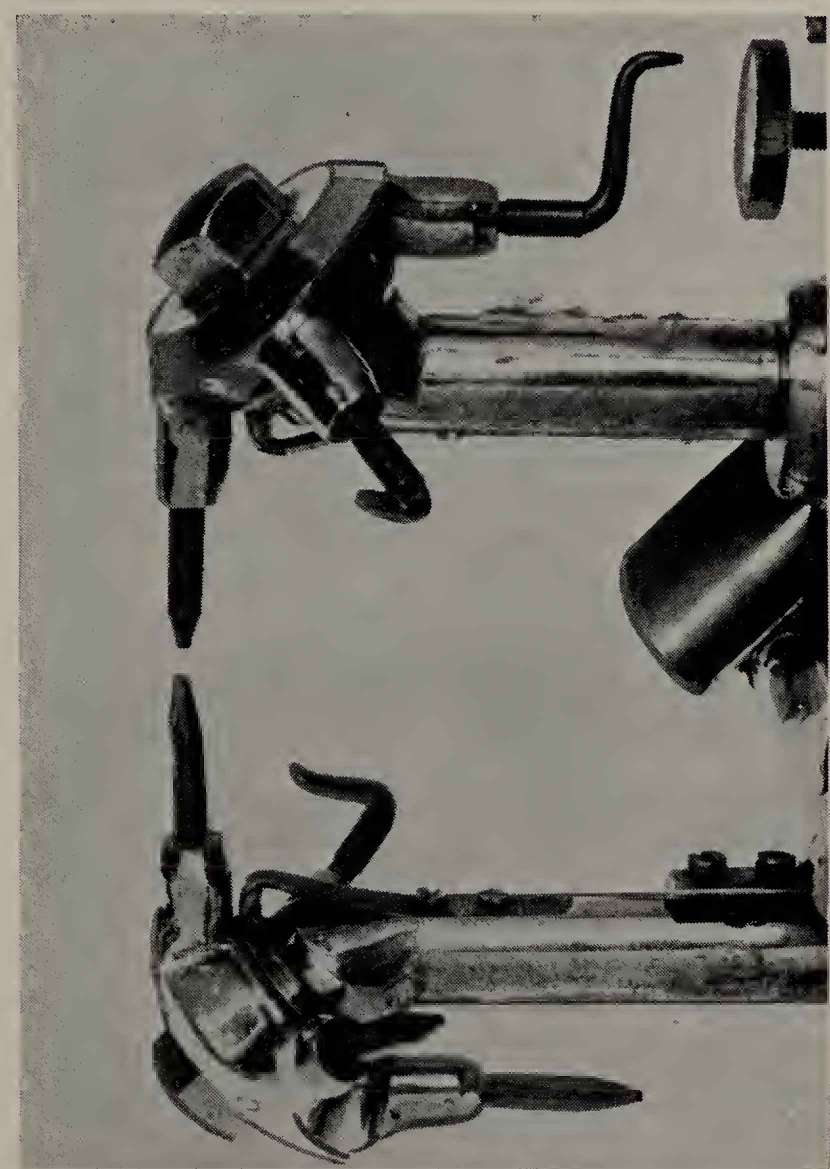


Fig. 5.—Electrode assembly.

4. The timing mechanism is usually a separate item even though it may be built into the machine.

The Electrode Assembly

Any factor in a welder which affects any of the parameters of current flow, resistance, and time of making the weld will affect the quality of the end product. In our recent study we found machines with the most stable electrode alinement gave the most consistent results in each

group—that is not to say, necessarily, that they made the best welds, but what they did do they did consistently. In the electrode assembly shown in *Fig.* 4, the stability of the rotating (capstan-type) turret heads is dependent on the resistance to displacement of a single set screw. This screw is unsatisfactory for its purpose and, especially as it is subject to wear, difficult to tighten. We found accurate alinement of upper and lower electrodes difficult to achieve. Lateral alinement in particular was very unstable and tended to allow some skidding of the electrodes on closure.

One welder examined had electrodes which were fixed in one invariable but stable position, with obvious disadvantages from the point of view of accessibility and rapid change of electrode combinations, but the consistency of operation of the welder was improved because of the electrode stability.

Fig. 5 shows what is perhaps the best electrode assembly of all the welders examined. Visibility is good, aided by the 45° angulation of the capstan-type electrode holders on the turret arms. Rapid change of electrode combinations is easy and accurate. The spring-loaded blade on the electrode arm engages the grooved slot on the capstan head to fix and stabilize each electrode position.

Classification of Welding Machines

At Sheffield we looked at twelve dental welders and classified them as follows:—

1. Machines energized by direct switching of the mains AC supply using either (a) non-synchronous controls (Nos. I–VI), e.g., Watkin and Dentaurum Junior, or (b), synchronous controls (Nos. VII–IX), e.g., Hirst and Slee welding machines.

2. Energy storage machines (Nos. X–XII) which use the rectified single phase mains AC supply, e.g., Rocky Mountain 600.

Energy storage welders work on the principle of storing up energy in a capacitor and releasing it, during a very short period of time, into the primary winding of the welding transformer. Welding is then independent of any fluctuation in the mains supply and, theoretically, consistency of welding is achieved by dispensing precise amounts of energy into successive welds.

Orthodontic welders with non-synchronous controls commonly use mechanical contactors to initiate current flow although we did have occasion to examine one welder with solid state switching in this category. These machines operate in an uncontrolled manner with respect to the zero of the mains voltage wave. *Fig.* 6 represents half a cycle of alternating current. The height of the curve at any point represents the value of the current at that point and switching of welding current with a particular point on this curve is purely a matter of chance. Obviously the machine operating during the time interval BC will probably produce a stronger weld than when operating during the time interval AB. The quality and consistency of welds from welders with non-synchronous controls thus becomes a gamble. The consistency will be improved when the welding time is for half a cycle or longer, but only at the expense of weld quality.

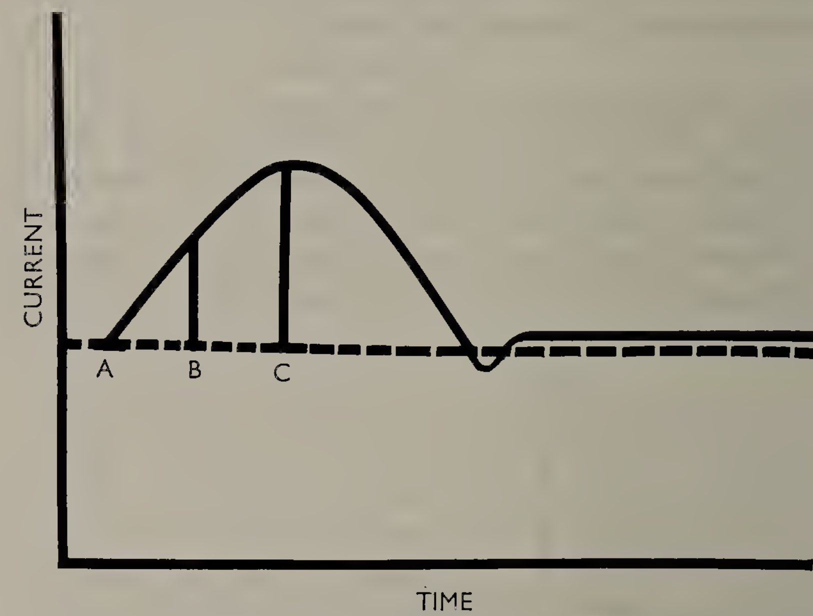


Fig. 6.—Diagram of half a cycle of welding current.

Other welders use synchronous controls to overcome these hazards by employing electronic tubes or solid state devices to open and close the circuit to the primary winding of the welding transformer. These always start and interrupt the current at exactly the same points in the voltage wave and so ensure high accuracy in the energy delivered for each welding operation.

EXAMINATION OF SPOT WELDING MACHINES

The examination considered those factors directly related to the performance of the machines and included a study of (1) electrode pressure, (2) the extent of the range of welding, (3) the consistency of operation of the machines, and (4) current flow with special reference to welding time.

1. Electrode Pressure

Foil strain gauges (*Figs.* 7, 8) were used to assess electrode pressure as under normal welding conditions. These work on the principle that when a conductor is stretched its resistance changes. When a strain gauge is bonded to the surface of a steel beam any strain in the beam brings about a change in the resistance of the gauge. A Wheatstone bridge network (in this case a Peekel bridge was used) is completed by resistances in the energizing supply circuit and reads the strain in micro-strain units. By calculation we can derive the load applied by the electrode to the beam and then calculate the pressure in lb. per square inch for a known area of

electrode tip. *Table I* shows some of the electrode pressures obtained. Notice that only one of the pressures comes near the minimum recommended pressure of 15,000 lb. per square inch. It was, in fact, possible to obtain even higher pressures with this welder. Higher pressures could also be obtained for welders VII and VIII by going beyond the indicator markings on the pressure adjustment carried on the welder head. Some of them were excessively low, of the order of 1470 lb. per square inch, and only three over 10,000 lb. per square inch.

2. Extent of the Range of Welding

The range of stainless-steel tape and wire over which the machines were able to weld was assessed by the use of simple destructive tests. The tearing test (*Fig.* 9) was used for stainless-steel tape. A weld was accepted as competent when the weld metal was torn out of one part and retained as a slug of metal in the other. A weld which showed little sign of attachment and was easily separated was accepted as a tack-weld. Browning or blackening, indicating over-heating of the work, was recorded as ‘ discoloured ’.

For the hard wire specimens we used the flexural bend test. A satisfactory weld was recorded when the break occurred at the margin of the weld and the other leg of the broken wire was still firmly attached (*Fig.* 10). As before, welds which separated easily were regarded as tackwelds only. Any discoloration of the metal was again noted.

The results of tests on 18/8 stainless-steel tape and wire are shown in *Table II*. Five weld

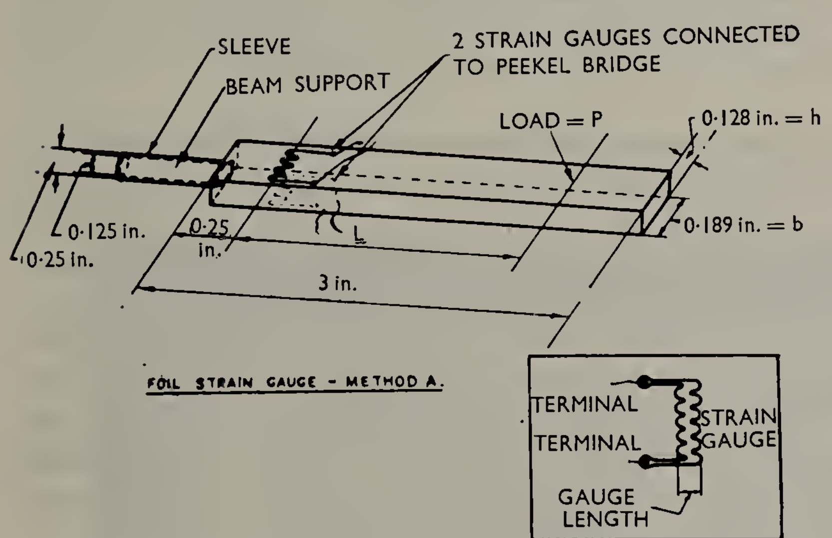


Fig. 7.—Diagram of strain gauges mounted on a steel beam. Inset shows a single strain gauge.

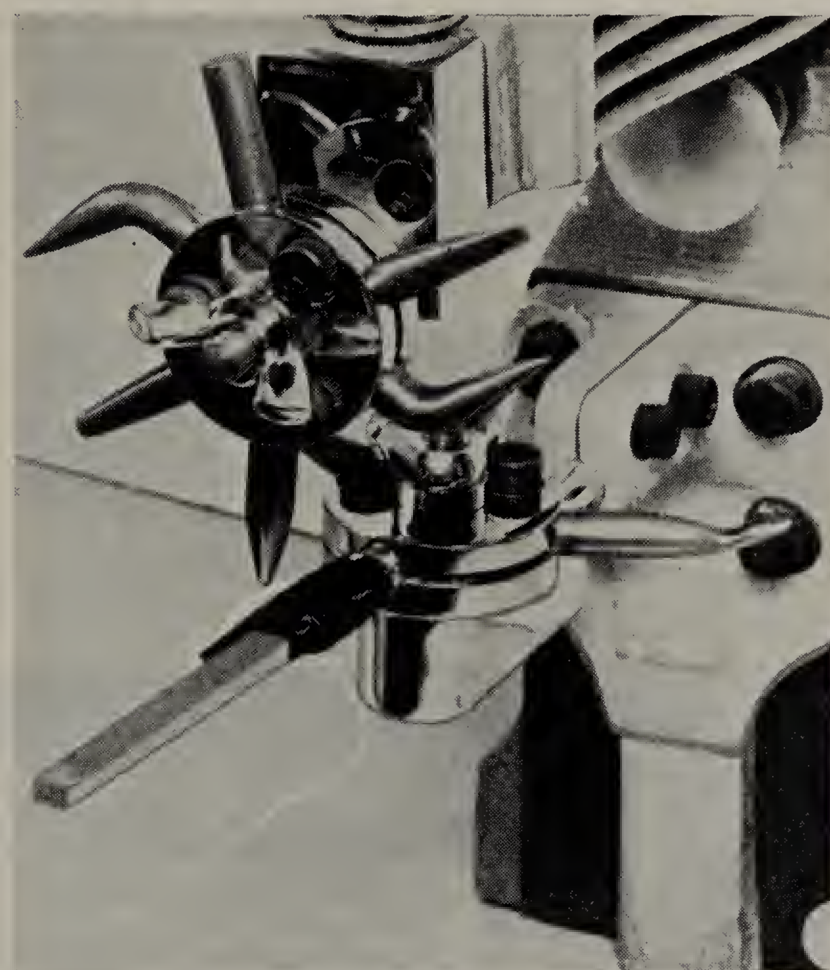


Fig. 8.—Beam, with strain gauge, mounted in the electrode holder of the welder.

Fig. 9.—Tearing test specimen at destruction.

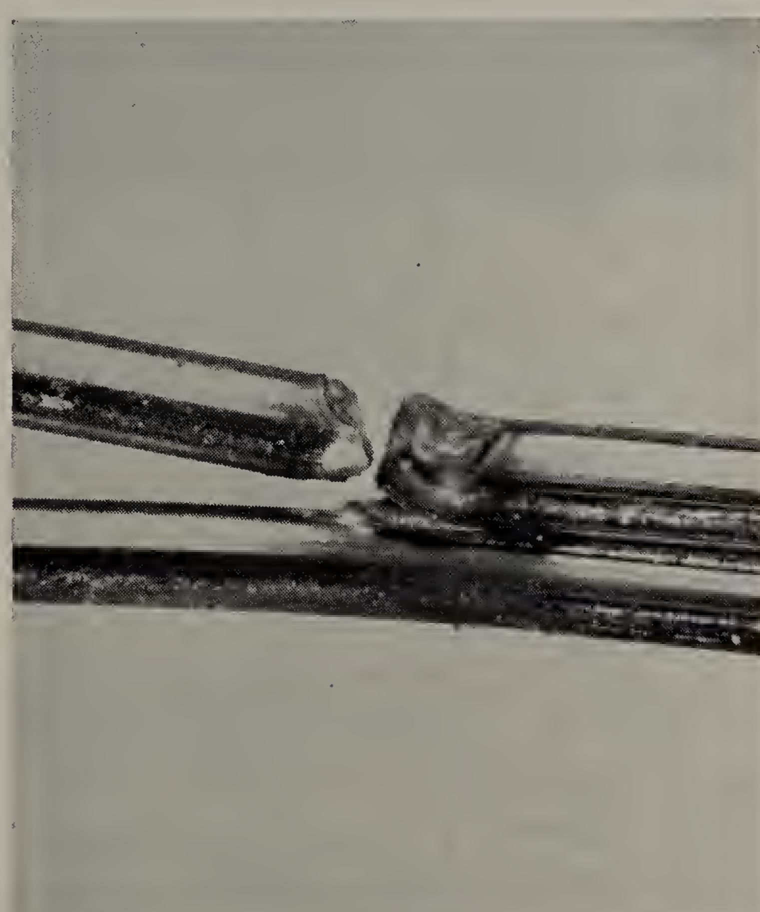


Fig. 10.—Flexural bend test specimen with the break occurring at the margin of the discoloured weld.

specimens were made for each grouping of stainless-steel wire and tape and the results of the tests were coded as W=a competent weld, T=a tackweld, and F=a failed weld. A letter D under a code letter shows that there was definite discoloration of the weld.

Welders I–VI with non-synchronous switching produced the most welds of poor quality. Only welder III managed to weld two pieces of 1 mm. wire and then on only 3 out of 5 occasions, and every weld was discoloured as were many of the welds from this welder. Welder IV which had solid state switching produced the best quality welds in the group but the range was limited and only tackwelding of paired wires 0·7 mm. in diameter and upwards was possible.

Welding machines VII, VIII, and IX had electronic controls and switching synchronized with the mains AC supply. Not one of the welds was burned and only welder VIII, with a non-variable welding time of 4·5 milliseconds, failed to weld the heaviest gauge wire.

Energy storage machines X, XI, and XII produced welds of good quality, related to short welding times of 1·5–4·5 milliseconds, but were restricted in range. Welder X failed to weld two pieces of 0·2-mm. tape and of the three energy storage machines not one successfully welded paired wires of 0·7 mm. in diameter.

Table I.—Welding Pressures

Welder No.	Load (lb.)	Pressure (lb. per sq. in.)*
I	2·28	1471
II	2·28	1471
III	21·8	14,110
IV	5·0	3226
V	(min.) 7·75	5000
	(max.) 11·0	7097
VII	(min.) 8·2	5290
	(max.) 21·4	13,806
VIII	(min.) 1·24	800
	(max.) 17·4	11,226
X	2·67	1723
XI	(min.) 7·75	5000
	(max.) 11·0	7097
XII	(min.) 2·5	1613
	(max.) 4·5	2903

*Pressures are calculated on the load applied by an electrode tip of 1 sq. mm. cross-sectional area.

3. Consistency of Operation of the Machines

The consistency of a machine's performance was judged by its ability to repeat a number of welds of equal strength when welding a standardized material. Tests were designed to measure the load at destruction of two welded pieces of 18/8 austenitic stainless-steel tape. This tape, 3 mm. wide and 0·1 mm. thick, in the soft condition and polished one side only, was supplied to specification EN 58E. A typical percentage

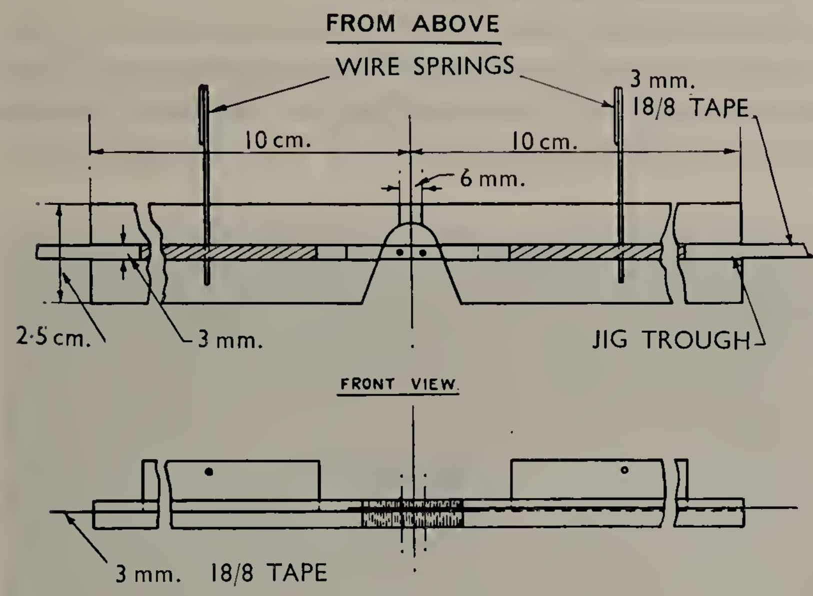
Table II.—Range of Welding: Test Results

Welder No.	Diameters of Hard Wire Welded (mm.) 0·4 to 0·4	0·7 to 0·7	0·7 to 1·0	1·0 to 1·0	Thicknesses of Tape Welded (mm.) 0·1 to 0·1	0·15 to 0·15	0·2 to 0·2
1a. Non-synchronous Switching							
I	WWWWT D D	WT T T T D	F T F T F	F F F F F	WWWWW D D	WWWWW D D	WWWWW
II	WF F WF D DD	T T T WT D DD	F F F F F D	F F F F F	WWWWW D D	WWWWW D	WWWWW D
III	F F F F W DDDDD	WWWWW DDDD	WT T WT D D D	F WWWT DDDDD	WWWWW DD D	WWWWW DDD	WWWWW D DD
IV	WWWWF	T T T T T	T T T F T	T T T T T	WWWWW	WWWWW	WWWWW
V	WWT WW	T T T WT	T T T F T DDD	F F F F T D DD	WWWWW D D	WWWWW D	WWWWW
VI	WWWWW	T T T T W	T T T T F D D	F F F F F DD	WWWWW D	WWWWW	WWWWW
1b. Synchronous Switching							
VII	WWWWW	WWWWW	WWWWW	WWWWW	WWWWW	WWWWW	WWWWW
VIII	WWWWW	WWWWW	WWWWW	T T T T T	WWWWW	WWWWW	WWWWW
IX	WWWWW	WWWWW	WWWWW	WWWWW	WWWWW	WWWWW	WWWWW
2. Energy Storage							
X	WWWWW	T F F T F	F F F F F	F F F F F	WWWWW	WWWWW	F F F F F
XI	WWWWW	WT T T W	T T T T T	F F F F F	WWWWW	WWWWW	WWWWW
XII	WWWWW	T T T T T	T F T F F	F F F F F	WWWWW	WWWWW	WWWWW

W=a competent weld. T=a tackweld. F=a failed weld. D=a discoloured weld.

analysis of this tape was, C, 0·05; Mn, 0·81; Si, 0·36; P, 0·026; Ni, 9·1; Cr, 18·4; S, 0·017.

All specimens were welded under standard conditions in the Perspex jig (*Fig.* 11). Two welds were made, 6 mm. apart, in the long axis



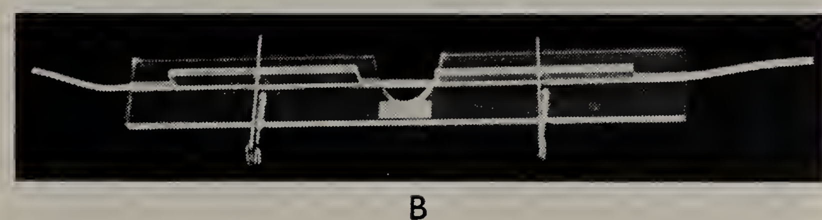


Fig. 11.—A, Diagrams (upper diagram, view from above; lower diagram, front view) and B, photograph of the jig used for welding the stainless-steel tape.

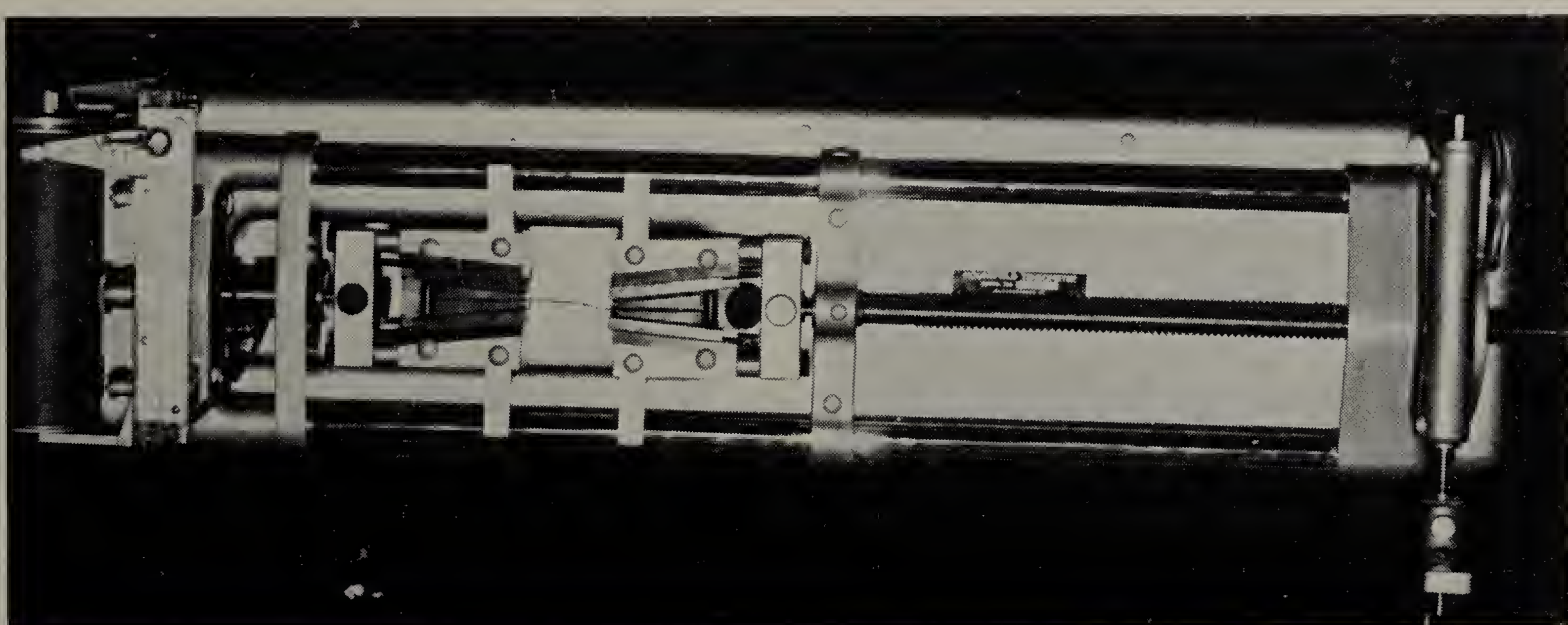


Fig. 12.—Hounsfield tensometer, type W.

of the tape and a standard Hounsfield tensometer, type W (*Fig.* 12) was used for the tests.

Groups of ten test pieces were prepared for a variety of welding values, i.e., current, time, and pressure for each welder. The breaking load required to separate each test piece was noted and a statistical coefficient of variation, which is expressed as a percentage, was derived for each group of ten test pieces. The coefficient gives an indication of the consistency of operation of the machines. The higher values are the least consistent, e.g., a welder with a coefficient of variation of 2 per cent would be regarded as much more consistent than one with a coefficient of variation of 10 per cent.

4. Welding Current Flow across the Electrodes

An oscilloscope gives a visible indication of conditions existing in an electrical circuit. The curve in *Fig.* 13A represents the voltage across the electrodes of a welder. The height of the curve at any point represents the value of the current at any instant of time; time being measured in a horizontal direction. *Fig.* 13B shows the same curve with a change in polarity and time. *Fig.* 13C illustrates the curve for the discharge of a capacitor welder and we can see an immediate rise to peak, followed by the sharp descent and levelling off of the curve. AB represents the essential discharge of the machine. *Fig.* 13D shows the welding curve with a subjacent reference curve of the mains supply (50 Hz) to enable measurement of the welding current by comparison.

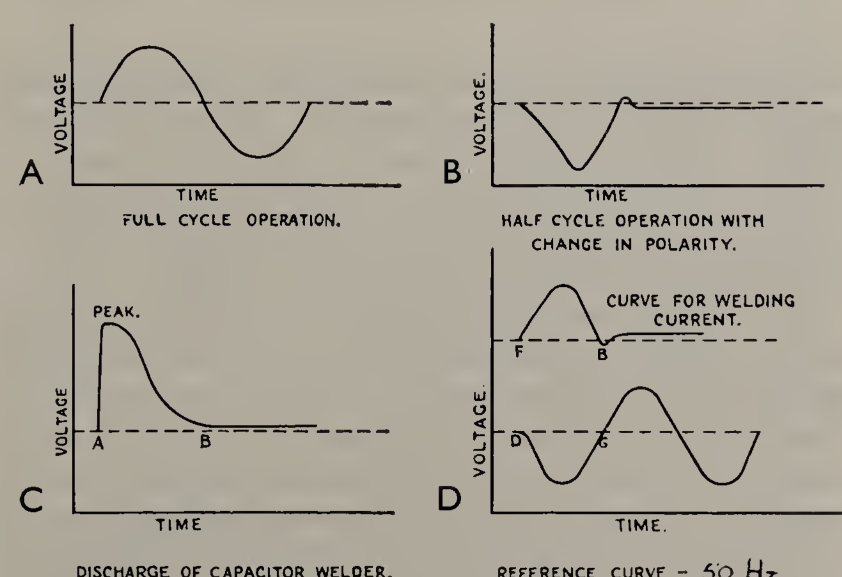


Fig. 13.—Welding current curve demonstrating A, Full cycle operation; B, Half cycle operation with a change in polarity; and C, Discharge of a capacitor welder. D, Welding curve (to p) compared with reference curve of 50 Hz (bottom).

DISCUSSION

Group 1a. Machines (I–VI) Energized by Direct Switching of the Mains Supply using Non-synchronous Controls

These machines were the most inconsistent in operation, giving the highest values for coefficients of variation and, one welder excepted, produced the poorest quality work of any group.

The first machine examined was particularly suspect. Switching was not only out of phase with the mains supply but the operator could vary the energy input into the weld by depressing the button toggle switch more quickly or more slowly. This machine gave two pulses of current, one pulse when the button was depressed and a second on its return after being released.

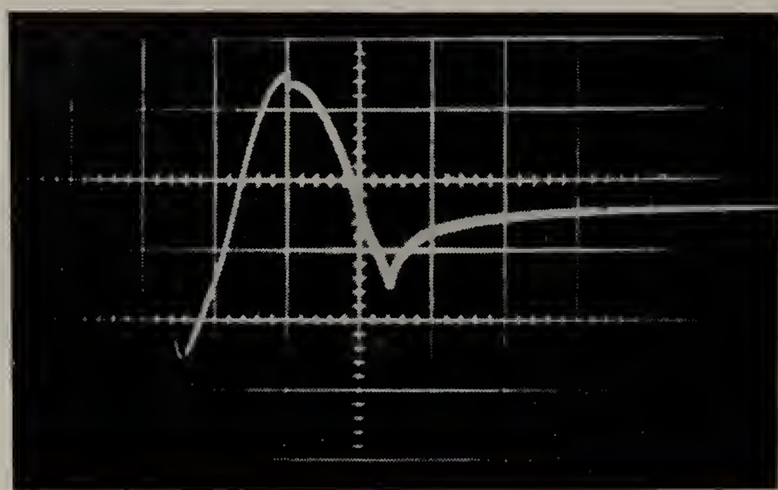


Fig. 14.—Oscillograph, commencing with a negative pulse.

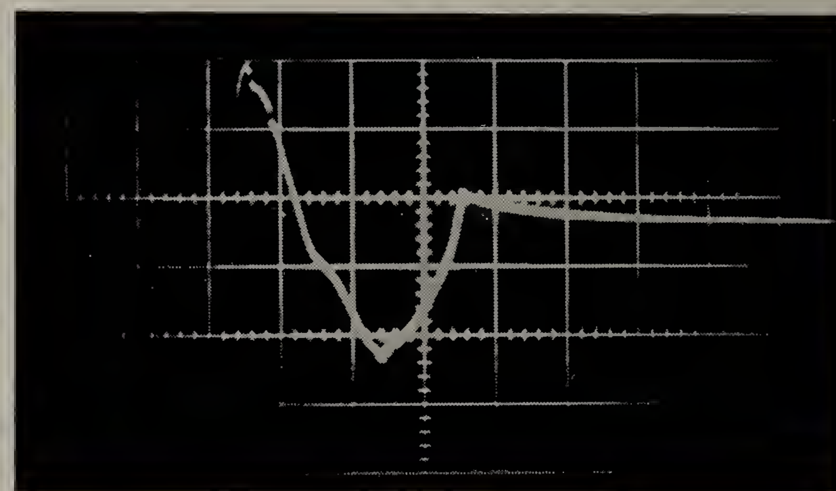


Fig. 15.—Oscillograph. Identical control settings as for *Fig.* 14, illustrating a reversal of polarity.

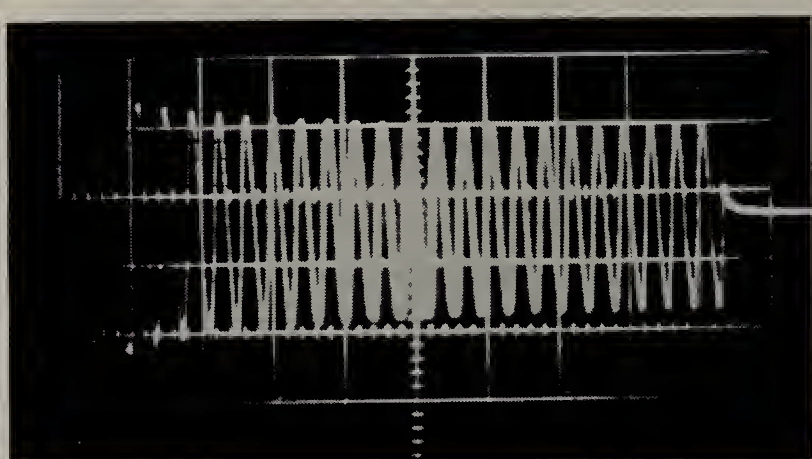


Fig. 16.—Oscillograph showing multiple pulsations of the welding current.

Fig. 14 is an oscillograph of the downward pulse which approximates to a full cycle (20 milliseconds) of the supply. The beginning of the trace is difficult to see but it starts on the left and descends below the level of the continuous horizontal trace seen on the right hand side. *Fig.* 15 is a repeat of the downward pulse with a change in polarity—the first part of the curve in this instance rising above the base line. This change in polarity is due to the switching not being phased with the AC wave of the mains supply. *Fig.* 16 shows a dramatic effect which caused severe perforation and burning of the test specimen. This is the result of accidentally lingering on the button switch and shows multiple pulsations amounting to 23 cycles of the mains supply. It emphasizes how the operation could be influenced by the operator.

Each current pulse of 20 milliseconds is too long and the electrode pressure is too low at 1470 lb. per square inch (as compared with a recommended minimum 15,000 lb. per square inch). Inconsistency and depreciation in weld quality is therefore not surprising. It is interesting that we were able to improve the quality of welding for this welder by simply applying manual pressure to the lower electrode.

The remaining welders in this group could not be influenced by the operator after the controls had been preset. The third welder caused the most frequent discoloration of the work by any welder, and this is no doubt associated with the excessive time factor. *Fig.* 17 is the first of two oscillographs for successive identical welding settings for this machine. The oscillograph shows one peak and a time interval which approaches one cycle of the supply (20 milliseconds). It takes a little imagination to see the difference between this and the second curve (*Fig.* 18). Here we see a number of peaks and a time interval which is obviously much longer. The shortest time recorded for this welder amounted to just below 20 milliseconds and the maximum time was 80 milliseconds or 4 cycles of the supply. The overall consistency of this welder is probably due to the long time factor and to the high energy input into the weld being sufficient to achieve weld strengths which approached the breaking strength of the stainless-steel tape, albeit at the expense of weld quality. The electrode assembly was also very secure and the welding pressure used for these tests was of the order of 15,000 lb. per square inch; the highest in the group.

The next welder (IV) in this group was energized by solid state switching of the mains

supply—that is to say switching of the welding current was done without the use of mechanical contactors. The electrode assembly was also very stable having spring-loaded, square-shaped turret heads which located into pre-determined positions.

There were four current settings and the time factor was internal and dependent on the welding current chosen. The shortest welding time approximated to 10 milliseconds but this was not constant for successive welds. The time intervals for welding current settings III and IV increased, but not uniformly, over those for settings I and II. The values achieved were inconsistent and far too long for accepted welding principles. *Table III* illustrates how the time of the welding pulse for current settings I and II varies between 10 and 20 milliseconds, and for current settings III and IV, there is an increased time factor which fluctuates between 20 and 30 milliseconds. It is noteworthy that the coefficients of variation for the two lower current settings are greater than those for the two higher settings which have longer welding times. The welding range was limited but the quality of welding was satisfactory with little discoloration of the work. This is surprising considering the long time factor.

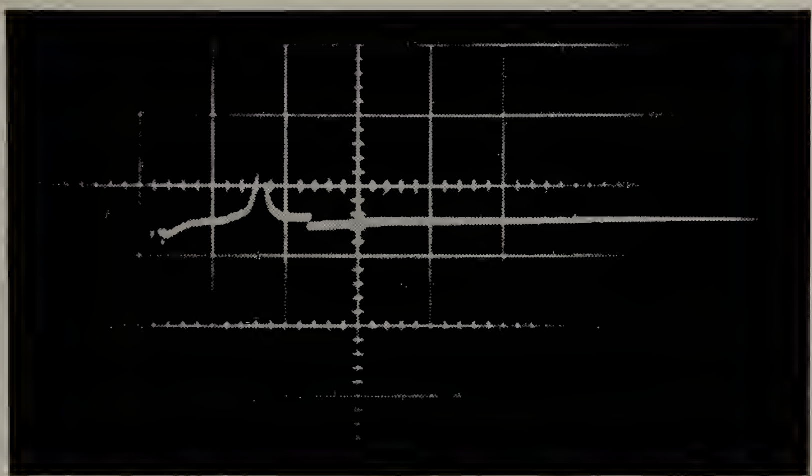


Fig. 17.—Oscillograph showing welding pulse for welder III.

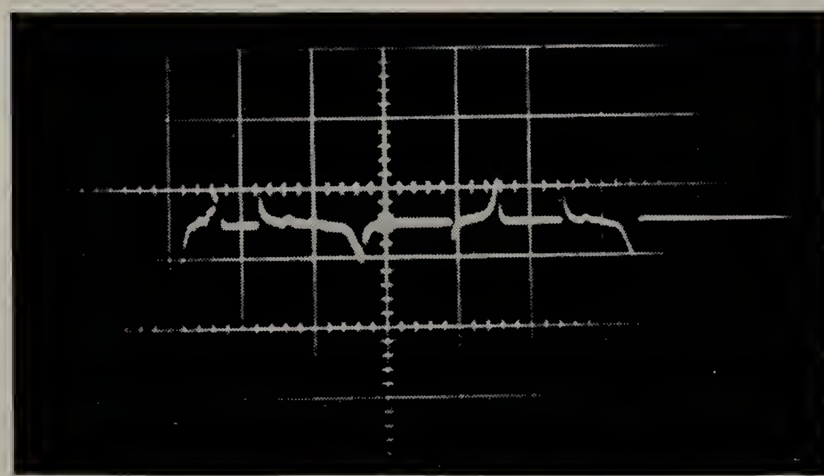


Fig. 18.—Oscillograph. Identical welder control settings as for *Fig.* 17.

Table III.—Welding Time Intervals for Successive Welds (Welder IV)

Oscillograph No.	Current Setting	Time (milliseconds)
1	I	20·0
2		15·0
3		11·5
4		10·0
5	II	15·0
6		16·0
7		10·0
8		10·0
9	III	24·0
10		18·5
11		18·5
12		27·5
13	IV	30·0
14		20·0
15		20·0
16		20·0

The last welder in this group is a pulsation welder in which one or more pulses of current are selected. It is energized directly by switching of the mains AC supply but out of phase with it. There is also an additional energy storage component included for small wires and so we have a dual welding system.

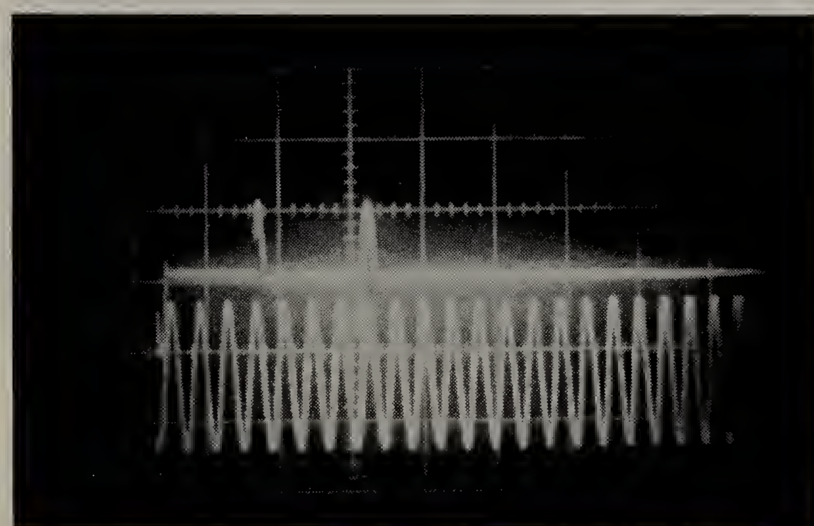


Fig. 19.—Oscillograph showing three pulses from a pulsation welder with subjacent reference curve.

The oscillograph (*Fig.* 19) represents a welding current (above the reference curve) made up of three pulses of current separated by two rest periods. The third pulse has both a negative and positive rise of the trace showing that there is some variation in pulsations which could cause differences in the weld quality and strength. The coefficients of variation obtained from one such welder varied between 3·2 and 13·7 per cent, and of a similar model between 2·3 and 5·1 per cent. The difference in consistency could possibly be explained, in part, by the greater stability of th electrode assembly for the more consistent welder.

The additional energy storage component for small wires was useful but the rationale of this dual system, of pulsation welding and energy storage welding, is difficult to see. A capacity storage welder of adequate power to encompass the whole range of welding would be more logical.

Group 1b. Machines (VII–IX) Energized by Direct Switching of the Supply using Synchronous Controls

Of the three machines examined, two employed electronic tubes and the third solid state switching

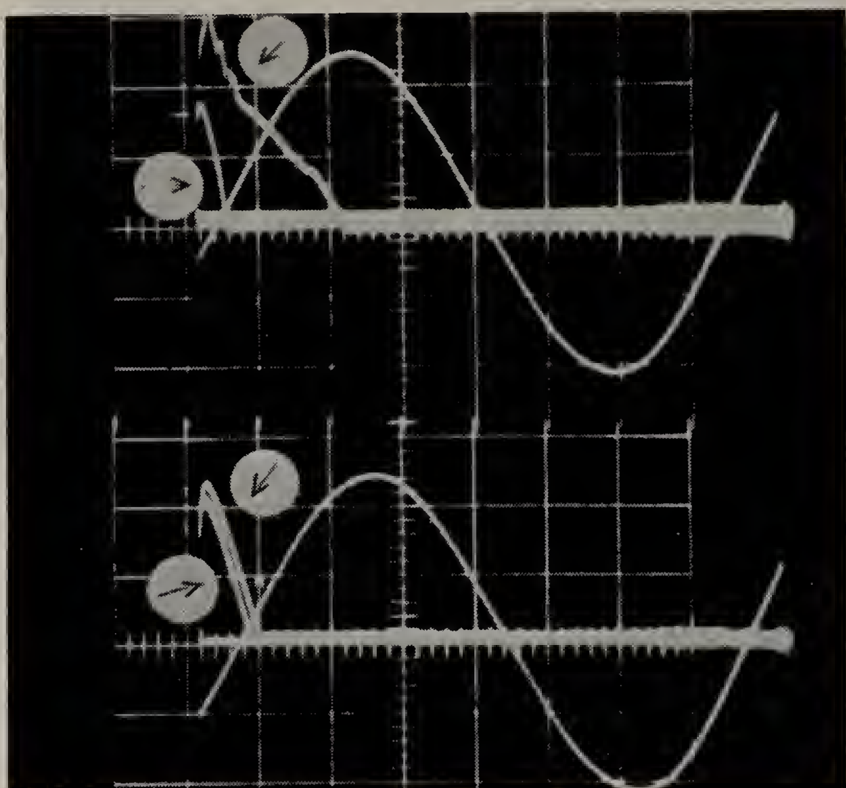


Fig. 20.—Oscillographs from a welder with synchronous switching of the mains supply.

of the supply. The latter had the obvious advantage of being immediately operational as no warm-up time was required.

Fig. 20 represents the welding current curves for various settings of one welder. Welding current curves for each pulse of current commence at the same position with reference to the voltage wave, whereas in the non-synchronous group of welders this relationship is a matter of chance. Two of these machines performed marginally more consistently than the third and it is again noteworthy that these had the more stable electrode alinement. The quality of all the welds, which were devoid of any obvious discoloration, demonstrated the value of high energy input into the weld for short welding times of less than 10 milliseconds.

In quality, consistency, and range of operation these machines excelled above all others. Only one of these machines failed to weld two pieces of 1 mm. wire and this is, no doubt, due to the reduced energy input into the welds imposed by the short (4·5 milliseconds) non-variable, welding time.

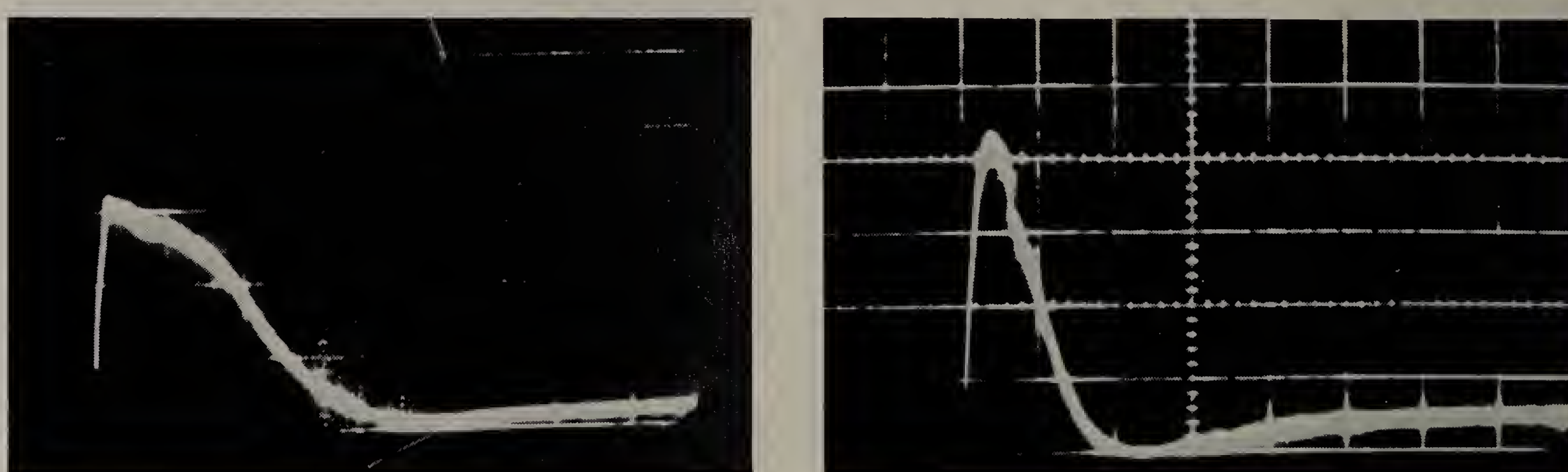
A short, invariable, welding time is contra-indicated unless the welding current range is sufficiently high to compensate for it. The time control in the other two machines was infinitely variable, from 0 to 10 milliseconds, as were the current and pressure adjustments for all the machines.

All three of these machines were bench mounted and from the orthodontist's point of view a major disadvantage could be their lack of portability although, for laboratory use, this is no real impediment.

Group 2. Energy Storage Machines

Examination of these portable energy storage welders (X, XI, and XII) established that the quality of welding was satisfactory but the range was restricted.

Fig. 21A represents a typical curve for the low setting of an energy storage welder. *Fig.* 21B illustrates the curve for the higher setting for the same welder. It is important to notice, in this one instance, that although the amplitude of the curve for the higher current setting has increased the time factor has been reduced by half so cancelling out, to some degree, the value of the higher current setting.



A B

Fig. 21.—Oscillographs of an energy storage welder. A, The low current setting. B, The high current setting.

Of the three machines examined, welder X was very under-powered for general orthodontic use (it could not weld 2 pieces of 0·2 mm. tape) and the electrode pressure was very low at 1723 lb. per square inch. Even so the consistency of operation, which could be related to very stable electrode turrets, was the most satisfactory of the energy storage machines. The other two welders in this group, though still limited in range, improved in this respect although the consistency of operation was reduced. This was especially true of welder XI which had coefficients of variation double that of welder XII and treble that of welder X. It is noteworthy that the electrode alinement of welder XI was the least stable of the three and the most difficult to aline, causing varying contact for successive welds.

CONCLUSION

There is a need for an efficient dental welder of portable dimensions which should be of the energy storage type or be energized by solid-state synchronous switching of the supply. It should have a more extensive welding range than those portable welders which are commonly available and be able to weld (in a time of less than 10 milliseconds) the full range of orthodontic tape and also wire up to a total of 2 mm. in cross-section (i.e., two pieces of 1 mm. wire).

All controls, including the pressure adjustment, should be infinitely variable and the electrodes should be able to apply a pressure of at least 20,000 lb. per square inch. A pressure adjustment with a calibrated indicator would be a useful aid to enable accurate repetition of successful welds.

A meter, to indicate the degree of stored energy, would be an asset to an energy storage welder. This would allow precise adjustment of welding energy and allow duplication of any previously executed weld.

Particular attention should be paid to the electrode assembly which should have spring-loaded turret heads of the capstan type and allow of rapid, accurate, and stable alinement for a variety of electrode combinations.

SUMMARY

The principles of resistance spot welding have been reviewed and a study made of the factors which affect the efficacy of twelve dental spot welding machines currently available.

Specific examination was made of factors which are directly related to welding ability and included a study of current flow with special reference to welding time, electrode pressures, the consistency of operation of the machines, and the extent of the welding range.

Recommendations are made for desirable features which should be incorporated in the machines.

Acknowledgements

The authors wish to express their appreciation for the invaluable co-operation of the departments of Electrical and Electronic Engineering, Mechanical Engineering, Metallurgy, and Probability and Statistics in the University of Sheffield. Our thanks are also due to Mr. J. Cousins of the Photography Department, the Charles Clifford Dental Hospital, and to those firms who loaned welders for this investigation.

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DISCUSSION

Dr. Atherton congratulated Mr. Tweedie on a fine paper. Mr. Tweedie had put in a tremendous amount of hard work into his investigations and also into preparing the material.

He himself could claim to be something of an expert on welders, in that he seemed to have worked with a number of welders which he regarded as inadequate.

He had noticed there was a difference in the way the arms of welding machines worked. Mr. Tweedie had divided them into two types; the type where one depressed the lower arm and the other type where, using the foot or other mechanism, one brought the upper arm down to make the union. Did Mr. Tweedie recommend one type or the other?

The second point arose from Mr. Tweedie's showing of the importance of the resistance and pressure. It was obvious the surface area of the electrode tips was an important item. Was there any particular area which Mr. Tweedie would recommend? Most orthodontists preferred to work with an extremely fine tip. Would Mr. Tweedie support that?

His third point was a very simple one. Reading through some of the brochures for welding machines, he had noticed on one capacitor welder it had been

stated that it was incorrect to weld twice in the same place. He admitted he had been in the habit of ' thumping the button ' two or three times to ensure a weld. Did Mr. Tweedie think that a single weld in the same place was sufficient?

Mr. Tweedie replied that whether one used foot pressure or hand pressure was a matter of preference but he found when welding fine wires it was very difficult to hold two pieces of fine wire between electrodes, remove one hand and press a button. It was far easier to hold the two wires in position with two hands and use a foot switch.

Regarding resistance, pressure, and electrode tip size, an electrode tip with a contact area of approximately 1·25 sq. mm. was a useful guide. Most electrode tips, if made too small, would eventually mushroom to an economical value.

On the question of two welds or two pulses of current through the welding point, the answer was that once the first weld had been made the resistance at the welding point would be reduced and additional welding pulses would only have a small incremental affect. Indeed, the point of greatest resistance could shift to the junction of the electrode tip and the metal to be welded and, possibly, cause fusion of the electrode and the metal.

Mr. G. H. Roberts congratulated Mr. Tweedie on a very interesting paper and on the tremendous amount of work which had gone into the paper.

Regarding Mr Tweedie's recommendation for an orthodontic welder, would this mean the machine would be very expensive?

Mr. Tweedie replied that, in life, the more valuable a thing was, the more one had to pay for it. Costing would depend on the degree of sophistication required and whether or not ancillary attachments such as for soldering or for heat treatment were to be included.

The President asked, if someone were to start from scratch and design a welder, would it need to be in the £1000 category. Could a machine not be produced for less than that?

Mr. Tweedie qualified his answer by pointing out that he was not a costing expert, but he felt it would be a figure well under £1000.

Mr. S. Haynes asked if, in Mr. Tweedie's view, orthodontists tended to put too many welds on brackets.

Mr. Tweedie replied that he was not an orthodontist and was not used to welding brackets, but the principle was this: if one put a large weld on a bracket or a band, the margins of that weld could come near to the edge of the metal and so predispose to early fracture. It was also far better to use two or three small welds than one large weld as these would be more resistant to shearing stress.

Mr. J. Pettman asked if Mr. Tweedie felt there was any place for ultrasonics in the dental side of welding.

Mr. Tweedie replied that there was a place for ultrasonics in welding but it would be very limited in dental welding.

Mr. Pettman had seen a television programme showing some excellent fine welding of dissimilar metals using ultrasonics. He wondered if they might benefit from Mr. Tweedie's advice on the matter.

Mr. Tweedie said he had discussed the matter only with a welding engineer. He had never experienced ultrasonic welding. He did not think, at this time, it would be a practical proposition in dentistry.

THE ORTHODONTIC PROBLEMS IN BURMA

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BURMA is an independent republic of South-East Asia, consisting of Burma proper and 5 states, being formerly a kingdom and then a territory of the British Empire. Burma became an independent nation completely outside the British Empire and Commonwealth on January 4, 1948 and is now a republic known as the Union of Burma. Burma occupies an area of 261,789 square miles and is sandwiched between India and China. It is bounded on the east by Thailand, Cambodia, Laos, and Vietnam, on the west by India, Pakistan, and the Bay of Bengal, and on the south by the Andaman Sea and the Gulf of Martaban.

Climate

The climate throughout is tropical with a well-defined rainy season from May to October. The rains accompany the south-west monsoon which comes from the Indian Ocean. The hottest season of the year comes immediately before the rains in March, April, and May when temperatures of over 100° F may be expected. December and January are the coolest months when temperatures may fall to 65° F. In upper Burma, however, hill stations at altitudes ranging from 1000 to 4000 feet provide a cool and pleasant climate.

Religion

The Burmese are mostly Buddhists and their religion occupies a large place in their life. The spiritual head of every village is the saffron-robed monk or pongyi. Every town and village has its pagoda, and gilded pagodas and shrines crown almost every hill.

Christianity has made some advance, especially among the Karens.

Customs and Culture

Most people live in villages in houses of bamboo and thatch on stilts but in big towns there are modern buildings.

The national dress is a long skirt called a longyi which is similar to a sarong and is worn by both sexes. Women wear a blouse called an aingyi and men wear a collarless shirt and a jacket for formal occasions.

As a whole the Burmese are characterized by cleanliness, a sense of humour, and a love of sport. Pagoda festivals and the funerals of famous monks attract great crowds. These are entertained with traditional drama, dancing, and clowning of high merit, combined with the theatrical performance which has many of the vital characteristics of the old-fashioned English music hall.

Agriculture and Industry

Essentially an agricultural country, the Burmese economy is dependent largely on the production of rice. Farming is an important occupation. Rubber is another important product, and forests occupy as much as 56 per cent of the total land. Valuable timber, mainly teak, was an important export before the war. Pre-war Burma was a large producer and exporter of petroleum and petroleum products, but this industry has not been rehabilitated since the war because of unsettled political conditions.

Normally an important exporter of minerals and precious stones, Burma since the Second World War has exported only relatively small quantities of lead, zinc, and tin. Precious stones include the famous rubies, sapphires, jade, diamonds, emeralds, and pearls.

Fisheries and fish-curing exist along the coast and rivers of Burma, and fishing is a valuable part of the nation's economy.

The chief arts of Burma are lacquer ware, wood and ivory carving, silverware, and pottery (earthenware). Many varieties of vegetables are available and fruits are found in abundance. Such fruits include a variety of melons, pineapples, lemons, bananas, mangos, mangosteens, durians, oranges, strawberries, custard apples, sugar-cane, and coco-nuts. The flowers are beautiful and they include exotic orchids, lilies, roses, gardenias, and jasmine.

Presented at the Country Meeting held on 16 May, 1970.

Diet

Salted fish, fish paste (Ngapi), and dried prawns along with boiled rice or noodles form one of the chief items of food among the Burmese. Burma before the last war was known as the ' Rice Bowl of Asia ', the world's greatest producer of rice; now, however, the Burmese people queue up for their monthly ration of poor quality rice which is also inadequate for their needs. Meat, poultry, fish, fruit, and vegetables are so expensive that the average Burmese cannot afford to buy these essential food items. Fresh milk is not easily available and powdered milk is rationed.

Their diet is extremely high in carbohydrate obtained from rice, sweet potatoes, and tapioca, but sadly lacking in first class protein, fat, and vitamins, which naturally leads to malnutrition among all age-groups. The effects of malnutrition were evident in the clinical material I came across during my year in Burma.

The Dental Problems in Burma

The Burmese Government, faced with a situation in which there are some 30 qualified dentists to care for a population of 25 million, were anxious to begin a crash training programme. The dimensions of this programme unfortunately hopelessly outstrip the available training facilities.

Burma's first dental school (*Fig.* 1), was opened in November, 1964 (Menezes, 1968) and 18 students were enrolled that year. Sixteen of these qualified last September (*Fig.* 2) and approximately the same number will qualify this year. Although this number is already overtaxing the resources of the Dental School, the Burmese Government has increased the annual intake of students to 50, which will make the whole training programme impossible unless the number of staff, dental units, and accommodation are drastically increased.

The Dental School had no trained technicians apart from the instructor technician from the United Kingdom. There were no trained nurses, chairside assistants, or hygienists. At present, however, there are 4 dental technicians undergoing a course of training in this country, and in order to augment the programme of prevention, 4 nurses have been sent to Singapore to train as dental auxiliaries. On their return to Burma they will provide treatment consisting mainly of prophylaxis and simple amalgam and zinc oxide restorations.

Fig. 1.—The Dental School, Rangoon.

It is the policy of the Burmese Government to invite lecturers from this country to help in the teaching programme at the Dental School. I took up my appointment in Rangoon in October 1967 for 1 academic year and my duties were to give lectures, tutorials, and clinical and practical work to students in their clinical year in orthodontics and children's dentistry. I also had to train 3 orthodontic technicians. Facilities for carrying out my work were inadequate and on my own initiative I had taken out equipment and materials on loan from the Birmingham Dental Hospital, without which I could not have introduced orthodontics into the student's curriculum. The economy of the country is such that government funds are not readily available for buying equipment and general running of the hospital. They rely to a great extent on overseas aid programmes provided by the United Nations, W.H.O., Colombo Plan, and other organizations.

Dental survey work was carried out not only at the Dental Hospital, but also in schools in Rangoon and surrounding districts with the intention of gaining statistical information on the state of the dentition, periodontal disease, and types of malocclusion among children from vastly different backgrounds. For the purpose of this survey it was decided to use the same record cards, the same method of examination, and the

same criteria as those used in all surveys carried out by the Department of Dental Health, University of Birmingham. The senior clinical students were taught to conduct a survey of a similar nature on a village population as these are the areas they are expected to work when they qualify.

among the Burmese and this is reflected in the present analysis which shows that 63·5 per cent of cases were classified as being Angle Class I. For the purpose of comparison the figures quoted by Mak (1969) of a mixed population, predominantly Chinese, in Hong Kong are very similar to those of Burma namely: Class I, 66·86 per cent; Class II, division 1, 13·42 per cent; Class II, division 2, 0·86 per cent, and Class III, 18·86 per cent.

Fig. 2.—The staff and graduates of the Dental School in 1969.

Although malocclusion is a severe problem, there are some gross pathological conditions which are even more severe—gross caries, acute ulcerative gingivitis, cancrum oris (gangrenous stomatitis), osteomyelitis, facial clefts, and fibrous dysplasia. When compared with British children, Burmese children appear to have less than half as much dental caries and 50 per cent more periodontal disease. This is largely the result of poor living conditions, poor diet, and lack of oral hygiene.

An analysis of the cases attending for orthodontic treatment in Rangoon was as follows: 59 per cent female and 41 per cent male. These percentages correspond very closely with those of Birmingham children who attend for treatment in the Orthondontic Department at the Dental Hospital (Foster and Day, 1969). Angle's classification is shown in *Table I.*

It is interesting to note the low figure for Class II, division 1 and Class II, division 2 cases and the high proportion of Class III cases presenting for treatment in Rangoon. Crowding was the most frequently encountered anomaly

Table I.—ANGLE'S CLASSIFICATION

CLASSIFICATION	PERCENTAGE OF CHILDREN	
	Rangoon	*Birmingham*
Class I	63·5	36·7
Class II, division 1	19·8	37·6
Class II, division 2	2·3	16·8
Class III	14·2	7·6

I have in many ways enjoyed my year in Burma. The Burmese were extremely kind and hospitable to me and my family. The Burmese Government provided us with a beautiful house in picturesque surroundings and also a car and a driver. But even here we came against a problem which is common to all in Burma, although the driver is good, the cars are not and as spare parts are not available breakdowns occur regularly.

However, one can always resort to other means of transport. As a whole my year in Burma, both professionally and socially, was a wonderful experience.

Acknowledgements

I would like to thank Mr. T. D. Foster for his comments and encouragement and Dr. R. J. Anderson for help with the processing of data which was collected. I would also like to thank my wife, not only for her secretarial assistance, but also for her valuable help with the photography.

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THE CLINICAL MANAGEMENT OF THE FRÄNKEL APPLIANCE, F.R.1

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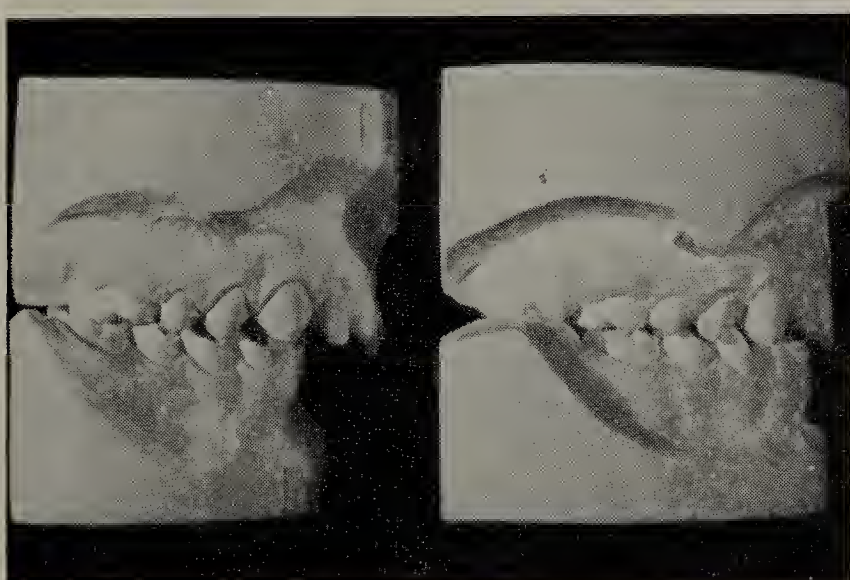
ORTHODONTIC treatment of Class II, division 1 malocclusion using Fränkel's Functional Regulator (F.R.1) induces a self-correction of malocclusion (*Fig.* 1 A, B) by modifying the muscular and skeletal environment of the developing dentition



A B

Fig. 1.—A, Disto-occlusion reduced during 20 months of wearing F.R.1. The mandible cannot be forced behind the new position. B, Arch widening occurring during 20 months of wearing F.R.1, no portion of which is in contact with the lingual aspect of the teeth.

(Fränkel, 1963). The modification in mandibular position is in the first place postural but continued development in the new environment induces permanent osseous changes (Ware and Taylor, 1968). These changes may be located in the alveolar process but both neck and condylar regions of the mandible and the articular surfaces of the temporal bone may also be the seat of permanent changes of shape (Baume and Derichsweiler, 1961; Furstman, 1965; Charlier, Petrovic, and Herrman, 1968, 1969).

The new position of the muscles dictated by the appliance, monitored and controlled by the neuromuscular background, may also, by changes in the cybernetic control system, produce a permanent alteration in the location, bulk, and action and therefore stress content of the muscles of the face, tongue, and neck which constitute the environment of the developing dentition (Timms, 1965).

The Functional Regulator of Fränkel (*Fig.* 2) has been described elsewhere on a number of occasions (Logan, 1967; Fränkel, 1969a,b).

The Angle Class II, division 1, type of malocclusion may be said to consist of four elements;

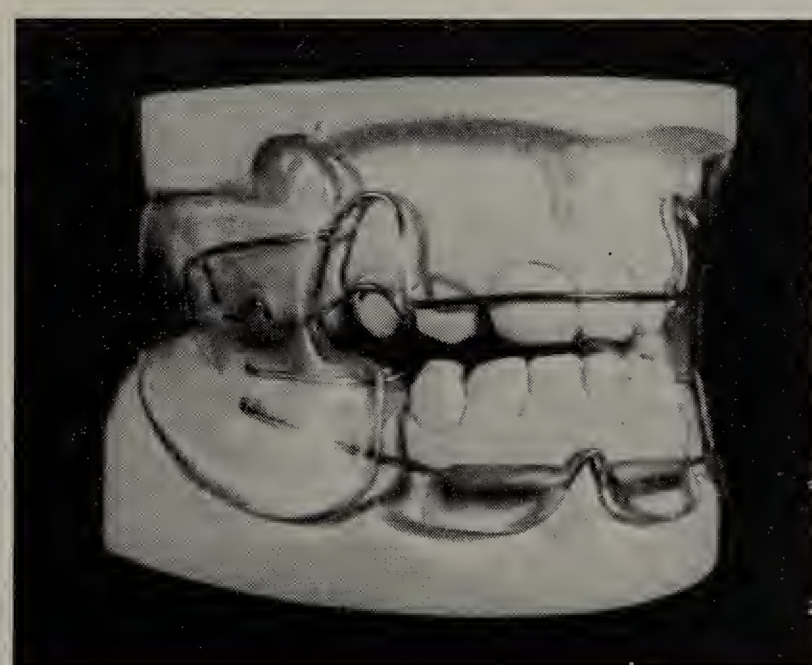


Fig. 2.—Functional Regulator 1. The upper cast is not correctly placed in the appliance. The upper and lower incisors should be in contact.

Presented at the meeting held on 21 April, 1970.

protrusion of the upper incisors; a narrowness or contraction of the upper arch particularly in the region of the premolars but also to some extent extending to that of the molars; disto-occlusion, and a deep overbite. We have for over half a century been able to treat this condition bringing all four elements to normality by making use of a technique which is difficult and exacting and requiring a high degree of training in the operator, As in all procedures requiring a high degree of manual skill, unless the operator has a constant stream of cases in his care he is apt to find that with lack of practice his skill diminishes and the treatment technically becomes irksome and liable to failure. This form of treatment therefore tends to be confined to those practitioners who are doing a lot of orthodontics, and the general practitioner with the occasional case and without the considerable degree of training which is necessary for the more exacting technique tends to solve the problem in another way.

To the patient the most striking element of the malocclusion is the overjet, and the occasional orthodontist tends to treat the condition by reducing the upper arch by the extraction of 2 upper first premolars and retracting the 6 upper front teeth to contact with the lower incisors. To the lay eye the dentition looks much more agreeable, the treatment is not lengthy, and for the operator is not technically exacting. The disadvantage of this method is that the deep overbite is liable to be increased. From the mechanical point of view this is a disabling conformation as far as the efficiency of the dentition is concerned.

Dr. Rolf Fränkel (1963, 1969a,b) has recently shown us how by the use of a removable appliance it is possible to induce a self-correction of this malocclusion by modifying the muscular and skeletal environment of the developing dentition. This form of treatment differs radically from orthodontics as we generally practise it in that, where we have hitherto concerned ourselves with moving teeth into positions which we deemed correct by means of more or less ingenious mechanical devices designed to put pressure on the teeth, in Fränkel's method there is no pressure put on the teeth by the apparatus which merely releases the dental arch from the constraint of an unfavourable environment.

In a word, we must transfer our skill from the moving of teeth to helping the patient to tolerate the treatment. We are not treating a malocclusion but a child.

I think you will all agree that the result of any medical treatment is the product of the mutual reaction of the personalities of the healer and of the patient, and it is of the utmost importance to establish a close psychological relationship with the child so that the child can freely and with the utmost confidence discuss his difficulties before and during treatment, while the orthodontist can do the same knowing that the patient will respond in an atmosphere of the utmost mutual confidence.

In order to achieve and maintain this psychological atmosphere I never have child and parent in the room together. Anyone who has worked with children will know that a child in the presence of the parent is in an atmosphere of psychological constraint and only those who have worked with children in the parent's absence will understand how much easier it is both for the child and for the operator if the personality of the parent is not interposed.

At the initial visit the parent is seen first and an attempt is made to evaluate the parent's grasp of the orthodontic problem. This may vary from the one who says that she knows nothing about it and that she thinks her child's teeth look all right and that the dentist simply told her, or in some cases sent a message to her saying that the child had better see an orthodontist, to the mother who says that her child's front teeth stick out and that the girl looks terrible. The parent is then sent out of the room and the child brought in. If the child will not come in alone this is taken as evidence that the child is psychologically insufficiently mature to profit from orthodontic treatment. Extra-oral and intra-oral X-rays of the incisor and canine region, where necessary, are taken and impressions made. The orthodontic diagnosis is then made in the presence of the child and with the help of the wet X-rays which are by now ready. It is decided that the case is an Angle Class II, division 1 malocclusion, whether or not all the teeth are present, whether there are any supernumeraries, and whether there is any element of crowding present. The lips are also carefully observed to see if there are any signs of environmental imbalance and whether there are any particular habits which are likely either to hinder or enhance the malocclusion. The question of sucking habits is also explored. This is best done by observing the child's hands and fingers and only if signs of maceration of the skin or of calluses are seen do I say to the child, 'I see you suck your thumb or your finger'. That concludes the initial visit.

I divide the subsequent handling of the case into five stages.

STAGE 1

In stage 1 the first thing is to quantify the motive of the child. It is possible by careful questioning and discussion to find out whether or not the child sees anything wrong with her teeth and whether she wishes to do anything about it. When it has been established that the child does see her disability and wishes to do something about it, then one gets the child to state this out aloud so that the child can hear herself saying it. Having established that the child wishes

orthodontic treatment we then proceed to explain the problem of wearing an appliance. It is stated that it will be uncomfortable to begin with and likened to wearing a new pair of shoes. The child is told that it will be like this for perhaps one or two days depending on the temperament of the child. The child will be told that the brace will be worn at all times except when eating, although to begin with it might be a good thing to wear it on coming home from school and during the night until the child feels more at home with it.

It is explained to the child that much of the success of treatment depends on keeping the teeth in the correct position and that we have a test of this which she herself can apply. This consists of the ability to speak clearly. The principle of auditory feed-back is explained to her. She is told that she will be given speech exercises to which she must listen very carefully indeed and that she must use her judgement in doing the exercises so that she always speaks well with the apparatus in place. It will be pointed out that if she fails to speak properly with the appliance in the mouth there is some failure of management on her own part with regard to the treatment. Finally, the child decides whether or not she is still willing to go through with this treatment and again she is induced to make a statement to this effect which she hears herself say. The operator then decides that the case is suitable for treatment and that the child is in fact a Fränkel case.

Not all children will ever arrive at this stage. Some of them will be prepared to think the matter over for a couple of months then will come back and, once more going through the routine, will finally decide that they are prepared to undergo treatment. Some will never think that the disability is worth all the trouble. It is, however, most important not to go beyond this stage until this has been clearly established both in the mind of the child and in the mind of the operator. This concludes the first stage.

STAGE 2

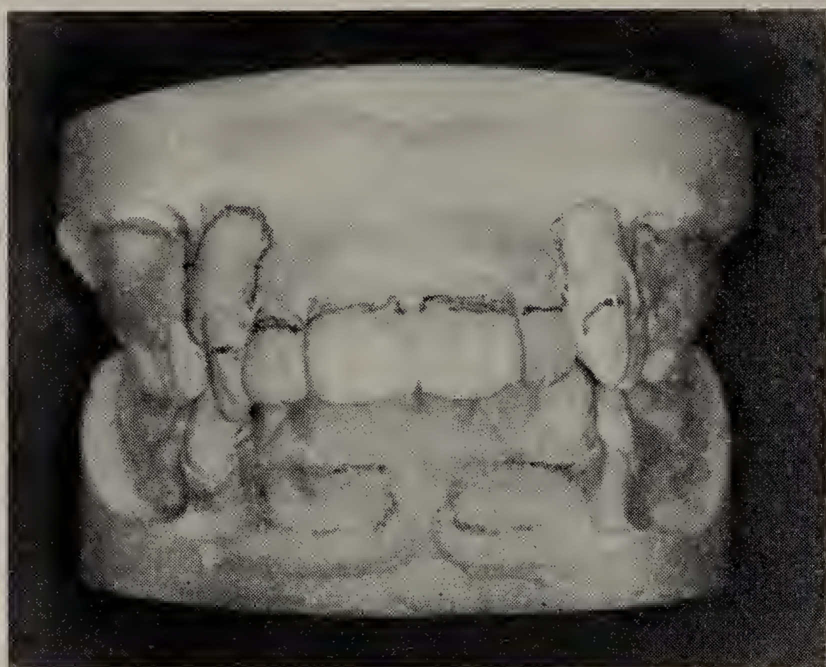
Stage 2 is concerned with the preparation of the appliance. At the initial visit of this stage, impressions for the working casts are taken. The impressions are taken on an anatomical basis with no muscle-trimming in any sense of the word. The whole height of the alveolar process must be carefully recorded and it is very important that the child is asked to relax the muscles of the lips while this is being done. Often the lower lip is tightened automatically and this will prevent the correct recording of the mucosa overlying the alveolar process in the apical region of the lower incisors.

At the next visit the child is seated on a stool in front of the operator who carefully examines the casts made from the previously taken impressions and compares them with the actual appearance of the vestibule of the mouth in the region of the lower incisors. It will be found that the mucous membrane has been pulled forward and that the actual position of the mucous membrane in relaxation is slightly further back to what appears on the cast. To counteract this the casts have to be scraped over the apices of the lower incisors and canines. This has to be done very carefully comparing the progress with the actual appearance of the gum in the patient's mouth. This procedure, of course, cannot in any sense of the word be accurate, but it is better to scrape the cast too much than too little so that when the appliance is finally made the clear acrylic will be found to press on the mucous membrane producing blanching of the mucosa. This can be relieved by reducing the thickness of the acrylic. If the models are not sufficiently scraped the pelottes will lie in front of the mucous membrane instead of actually on it (*Fig.* 3A).

The design for the appliance is then marked on the models. The position of the wire work and shields is marked with blue pencil (*Fig.* 3B, C). An upper labial bow emerges from the side shields over the roots of the canines and descends to make contact with the lateral incisors on the distal part, then runs forward just above the line of the gum papilla to the other side, and terminates in the lateral shield of the opposite side. The canine loops start on the mesial third of the labial face of the canine, run between the canine and the lateral, then in contact with the mucous membrane of the palate about 1–2 mm. distant from the gum margin, and finally back through the embrasure between the canine and first premolar, and so into the lateral shield. The palatal bow lies across the vault of the palate, clear of the mucous membrane, coming up mesial to the first molar, then turning into the lateral shield, and emerging again to form a spur lying on the occlusal surface of the upper first molar.

On the lower model the anterior pelottes or lip shields are first marked, their upper edge about 2 mm. below the gum margin in front of the roots of the canines and lower incisors. The lower edge is marked as deep as possible in the sulcus. This depth varies from child to child and one gets in time a certain amount of judgement as to how deep one can take the pelottes. In case of doubt, one should make the pelottes deeper rather than shallower as they can always be reduced but are not very easily added to. The labial wire work is then drawn in, running from the lateral shields forward, about 3 mm. below the gum margin, into the body of the pelotte and then rising in a loop over the fraenum and so continuing on the other side through the pelotte to the side shield. The lower lingual bow is marked, starting from the distal hollow on the lower canine just above the gum margin, across the cingula of the lower incisors to the distal hollow on the other canine.

Here there is a right-angle turn and the bow turns downwards and distally to form a loop over the apex of the first premolar, then returns upwards to pass over the contact point between the first



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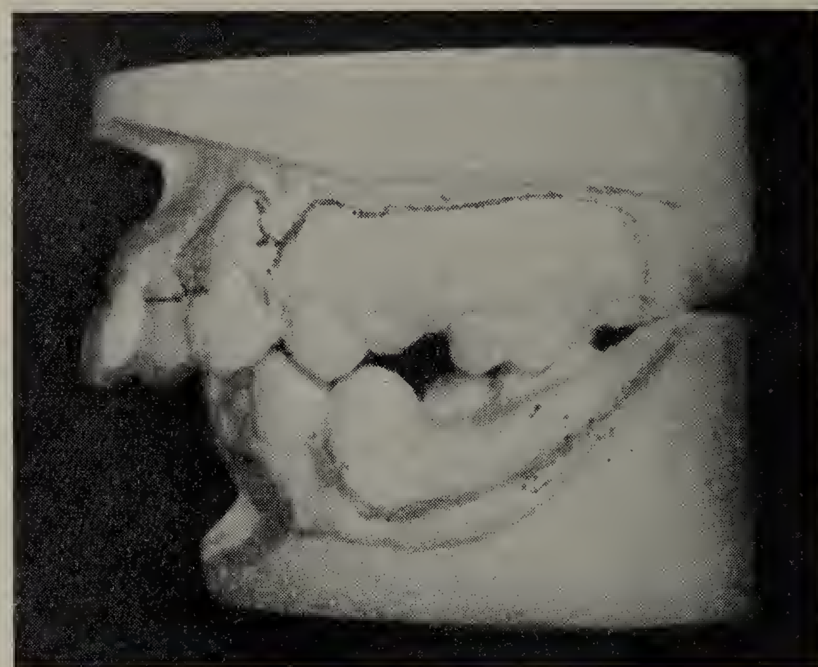
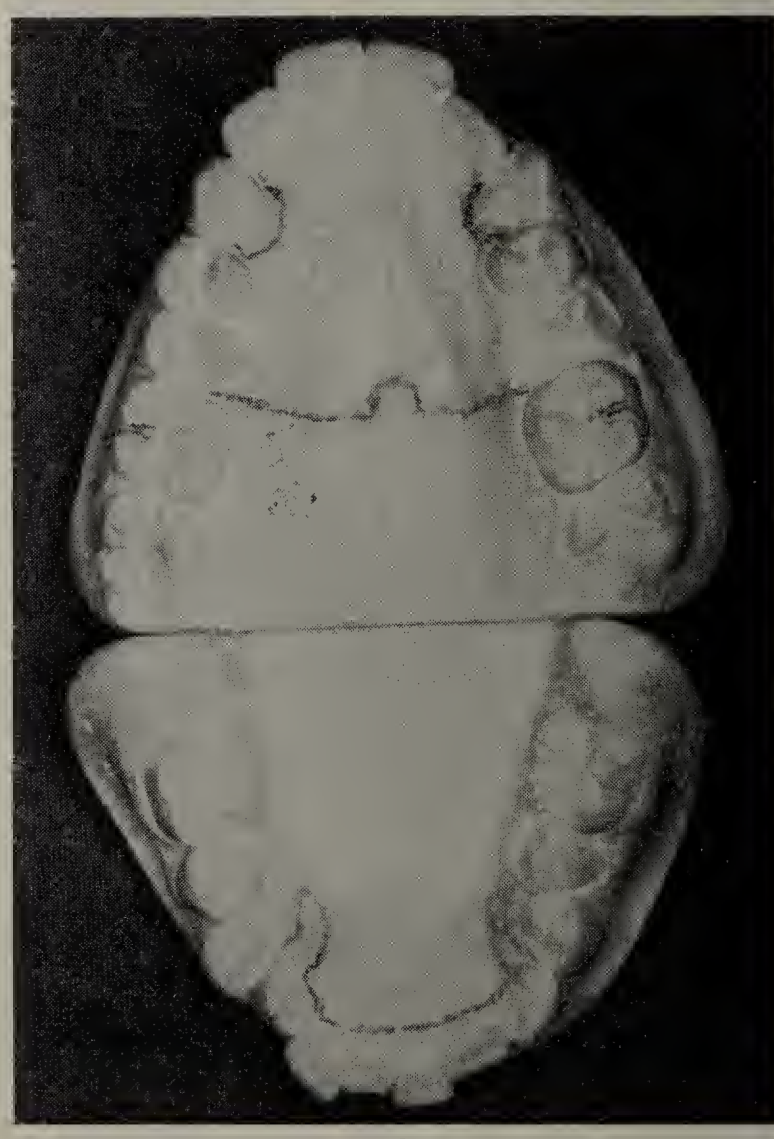


B

Fig. 3.—A, Working cast showing the scraping over the roots of the lower incisors, the marked location of the lip shields (pelottes), and the location of the upper labial bow. B, Working cast showing the marked limits of the cheek shield. C, Working cast showing the marked location of lower lingual bow, upper palatal stabilizer, occlusal rests on upper first molars, and upper canine loops.



C

premolar and canine and so into the lateral shield.

The lateral shields are then delineated. The upper shields stem from the embrasure between canine and premolar as high up as possible, if necessary cutting the model to achieve sufficient height, running horizontally backwards as far as the apex of the roots of the first or second molar, then coming down on to the lower model where they need not extend so deeply into the vestibule but run forward to the mesial of the lower first premolar.

The working bite is now registered. This is done by getting the child to bite edge-to-edge on the incisors unless the overjet is excessive, say more than 8 mm. In this case one would accept a working bite as offered behind the edge-to-edge occlusion in the first instance. There is usually no particular difficulty about registering the bite although there are some children who find it difficult to make the upper and lower centres coincident. These children may take a long time and it is well worth spending three-quarters of an hour in trying to get this working bite correct. The working bite must be registered with upper and lower incisors touching. The wax bite is then chilled and transferred to the casts which are bound together with a turn of Sellotape.

The child is then given a speech exercise which consists of a verse of a poem which has been chosen so as to contain as many sibilants as possible. The child carries this about in his pocket and is told he is to practise it as he is going to use it as a gymnastic exercise to get his teeth straight once he begins wearing his brace. He is reminded about the use of auditory feed-back. He is reminded that the sound will come out of his mouth, go to his ears, proceed from there to his brain, and there he has to appraise it. If the sound is not good then he is to recognize it

as such and try again to get the sound better. This is a very important control element in treatment which the child must operate personally. The child is also given a written explanation to take to his teacher so that when he comes to wearing the appliance in school the teacher will be fully informed as to what is happening. Finally the patient is sent out of the room and the parent is interviewed alone, told that the child will have his apparatus at the next visit, and is warned not to make any injudicious remark likely to put the child off, but to congratulate the child on having overcome his overjet and lost the appearance of toothiness on the first day.

STAGE 3

Stage 3 is that of the introduction of the child to the appliance. The purpose of this stage is to enable the child to discover from his own observations that the appliance is tolerable, that speech is possible, and that the overjet is reduced when the appliance is in place with a consequent improvement in his appearance. The child is brought in, asked if he remembers biting on his front teeth, made to do this, asked to open his mouth when the appliance is quickly slipped in by the operator, and then asked to shut gently on his front teeth stopping immediately if he feels any nipping or pinching by the appliance. From now on the appliance is never inserted or removed by other than the child so that if any nipping or pinching does take place it is quite evident that the operator has nothing to do with it. If the child indicates that there is some pressure and tightness the mouth is carefully examined. Owing to the use of clear plastic it is possible to see blanching taking place where undue pressure is being exerted on the mucous membrane. This is relieved by means of burs and stones, the child taking out and inserting the appliance himself. The apparatus continues to be adjusted until the child says it is perfectly comfortable. Usually the only adjustment that is necessary is to reduce the under surface and lower edge of the pelottes where the cast has been too deeply scraped.

The next procedure is to allow the child to discover that he can speak. With the appliance in place the child is invited to repeat the speech exercise which he was given at the previous appointment. This is recorded on a tape-recorder. Speech on this first occasion can either be surprisingly good or may be very bad. It is usually quite moderate. The child is then told to repeat the poem again and to listen carefully to himself speaking. Now the child is told that it is not necessary for him to speak in that peculiar fashion, that he can speak quite normally, but that he must remember to keep his lower jaw forward and his incisors practically edge-to-edge. He is then requested to repeat his exercise once again with the teeth in the indicated position and to listen carefully as he does it. It is pointed out that this effort is very much better than the previous ones. He is told once again about the auditory feed-back, reminded that the sound of his voice has to come into his ears and be appraised in his sensorium and that as a result of the appraisal he must make the appropriate changes to the position of his mandible. Once again he is invited to repeat his exercise this time with auditory feed-back working and this attempt is recorded. The speech by now is usually practically normal and the first recording and the second recording are now played over to him so that he can hear the difference. All this must be done carefully and slowly with careful checks to ensure that the child is assimilating what is said. It is no use hurrying over this business and not taking the child with you step by step.

Finally, the child wearing the appliance is invited to walk over to the mirror on the wall, stand 4 feet away from it, and to notice that his front teeth do not stick out any more. By now some 10 to 20 minutes have elapsed since the appliance was first placed in the child's mouth. At the beginning it was quite evident that the muscles of the face were strained by the new mandibular position but since then relaxation of the facial muscles has already begun to take place and the face looks much more natural (Eirew, 1969). The parent is now brought in, is allowed to look at the child from a slight distance, the child is invited to repeat his exercise, and it is pointed out to the parent that the child can wear the appliance with comfort, that he can speak properly when he tries, and that his front teeth don't stick out any more.

I now say to the child: ' Now would you like to start wearing the brace all the time at school and at night, or would you like to wear it only when you come home at night for a week until you get into the way of it.' I remind them that they will normally wear it all the time except when eating. They cannot eat with the appliance in place. Many children will elect to keep the appliance in and walk out of the room complete, but about a third will decide that they will prefer to start off wearing it when they come home from school and during the night. A box is given to the child and he is told that when he takes the appliance out of his mouth he must wash it carefully with soap and warm water, dry it, and place it in the box and on no account must he carry it loose in his pocket. The child is also warned that if the appliance begins to press like a new pair of shoes it may make a little mark on his mouth, in which case he is to continue wearing the plate and to arrange to see the operator as soon as possible with the mark still in being so that the adjustment can be exactly made. The patient is then given an appointment for 7 days later and dismissed.

STAGE 4

Stage 4 is the supervision of treatment and starts on the first visit after the appliance has been inserted. As the child walks into the room wearing the appliance it is very noticeable that there is complete muscular relaxation of the facial muscles. Indeed, one sometimes wonders whether the child is wearing the appliance or not. One then checks the comfort of the appliance and adjusts the pelottes and also the canine loops if necessary. Thirdly, co-operation is checked by the speech. The child is invited to say his poem and the quality of the sibilants is very carefully noted. The mouth is also carefully examined for pressure marks. It is very usual to see an area of hyperaemia in the lower lip fold where the pelottes are located and there may be marks of pressure from the pelottes, from the vertical ends of the cheek shields, or from the canine loops on the palate. Fourthly, with the appliance out the occlusion is checked in the canine region and the molar region on each side and the overbite and upper arch width are measured (*Fig.* 4A, B). In order to assess the change in the occlusion, measurements are made from the tip of the upper canines to the distal contact point on the lower canines. This gives a measure of the deviation from neutro-occlusion. In the same way the distance between the mesiobuccal cusp of the upper first molars and the buccal groove on the lower first molars is also recorded at each visit. Fifthly, as the child speaks it is carefully checked that he is consciously using the auditory feed-back. He may have to be reminded about this. Finally, the child is asked if there is any difficulty about the appliance coming out at night. A certain number of these appliances do come out at night initially and this can be cured by making use of a simple headgear including a tape tied under the chin. Usually it is not necessary to use this headgear for more than one or two nights, thereafter the appliance stays in place. I have never known it necessary to wear a headgear for more than a week. The patient is then dismissed for a fortnight and at the end of a fortnight this same procedure is gone over. The child is then dismissed for a month and so the course of the treatment proceeds. It is very often possible to make appointments 6-weekly once the child is confident.

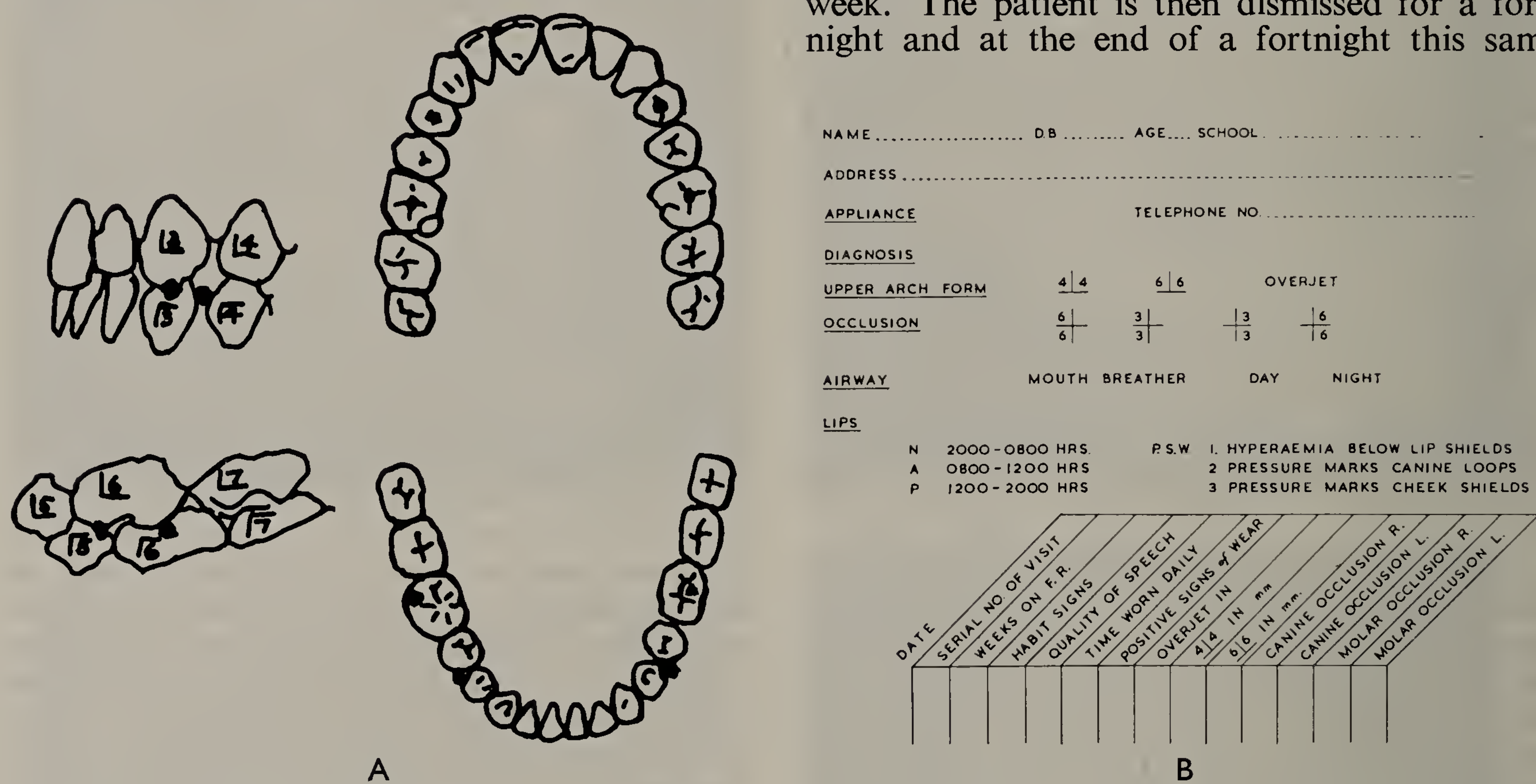


Fig. 4.—A, Measure points used in recording progress. B, Author's case sheet for recording course of treatment with F.R.1.

It is usually found that within a month there is a definite increase in the inter-premolar width and this continues for 3 or 4 months. It is also found that the overjet begins to decrease and the occlusion commences to change towards normality. By the careful measuring of the intermolar, inter-premolar width, and the overjet and careful noting of the occlusion, it is possible to see whether or not there is likely to be any success with the method. If the child is not able to manage the apparatus it will be found that in 2 months nothing has happened at all. Reduction of the disto-occlusion can take place in 3 months. It usually takes about 8 or 9 months during which time the upper arch widens by about 4 mm. It is interesting to note this widening of the upper arch is self-limiting, proceeding to a certain stage and no further.

STAGE 5

The final stage is that of stabilization. Once the occlusion is as near normal as it is likely to

reach then I make a new F.R.1 with a very slightly protrusive bite which is worn at night only. As to how long this is to be worn no one really knows but I think myself that the child should wear it until growth stops at about the age of 16 or so. I have never had a child object to this. The occlusion should be checked twice a year to make sure that it is stable and to ensure that no untoward development is occurring.

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VARIATION IN THE EXPRESSION OF HYPODONTIA IN MONOZYGOTIC TWINS

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INTRODUCTION

There is an extensive literature on the subject of hypodontia including a number of well-documented family histories such as those reported by Dahlberg (1937) and Townend (1955). Dahlberg referred to five generations in one family of 59 individuals in which 18 had congenital absence of the same teeth. Townend, on the other hand, reported a family in which there appeared to be an inherited predisposition to hypodontia, the extent and sites affected, however, varying between individuals in the family. The literature is well reviewed by Grahnen (1956), who also quotes several authors who have reported concordant hypodontia in monozygotic twins supporting the view that this condition is genetically determined. A variation in the expression of the hypodontia may occur even to the extent of an apparent discordance: Ritter (1937) described five such cases and Keene (1966) described

A B

Fig. 1.—First pair of twins, A, Carol and B, Jennifer.

Presented at the Research Meeting on 14 May, 1970.

another, but the basis on which monozygosity was established and the probability of a correct diagnosis were not discussed by either author.

One problem inherent in twin studies is that of establishing monozygosity. After consideration of the work of Cederlöf, Friberg, Johnsson, and Kaij (1961) the World Health Organization meeting of investigators on the use of twins in epidemiological studies (1966) concluded that general physical likeness could differentiate monozygotic and dizygotic twins at the probability level of approximately 95 per cent. Serological tests of blood samples were found by Cederlöf and co-workers (1961) to provide a means of establishing

Table I.—Probability Levels of Dizygosity

System	Carol and Jennifer			Janet and Carol			Susan and Penelope		
	Group	*Relative Chance of Dizygosity*		*Group*	*Relative Chance of Dizygosity*		*Group*	*Relative Chance of Dizygosity*	
		Individual*	Progressive		Individual*	Progressive		Individual*	Progressive
Initial Odds†		0·05	0·05		0·05	0·05		0·05	0·05
ABO	0	0·6891	0·0344	0	0·6891	0·0344	A_1	0·6470	0·0323
Rhesus	cDE/cde	0·4179	0·0143	CDe/cDE	0·4241	0·0145	CDe/cde	0·5400	0·0174
MNSs	MNS	0·5044	0·0072	MNSs	0·4556	0·0066	Ms Ns	0·4733	0·0082
P	P_1	0·8489	0·0061	P_1	0·8489	0·0056	P_1	0·8489	0·0069
Lutherian	Lu(a⁻)	0·9614	0·0058	Lu(a⁻)	0·9614	0·0053	—	—	—
Kell	K^+k^+	0·5218	0·0030	K^-	0·9548	0·0050	K^-	0·9548	0·0065
Lewis	$Le(a^-)$	0·8681	0·0026	$Le(a^+)$	0·5425	0·0027	$Le(a^+)$	0·5425	0·0035
Duffy	$Fy(a^+)$	0·8099	0·0021	$Fy(a^-)$	0·6235	0·0016	$Fy(a^+)$	0·8099	0·0028
Kidd	$Jk(a^+b^-)$	0·5732	0·0012	—	—	—	$Jk(a^+)$	0·8616	0·0024
Final Odds			0·001			0·002			0·002

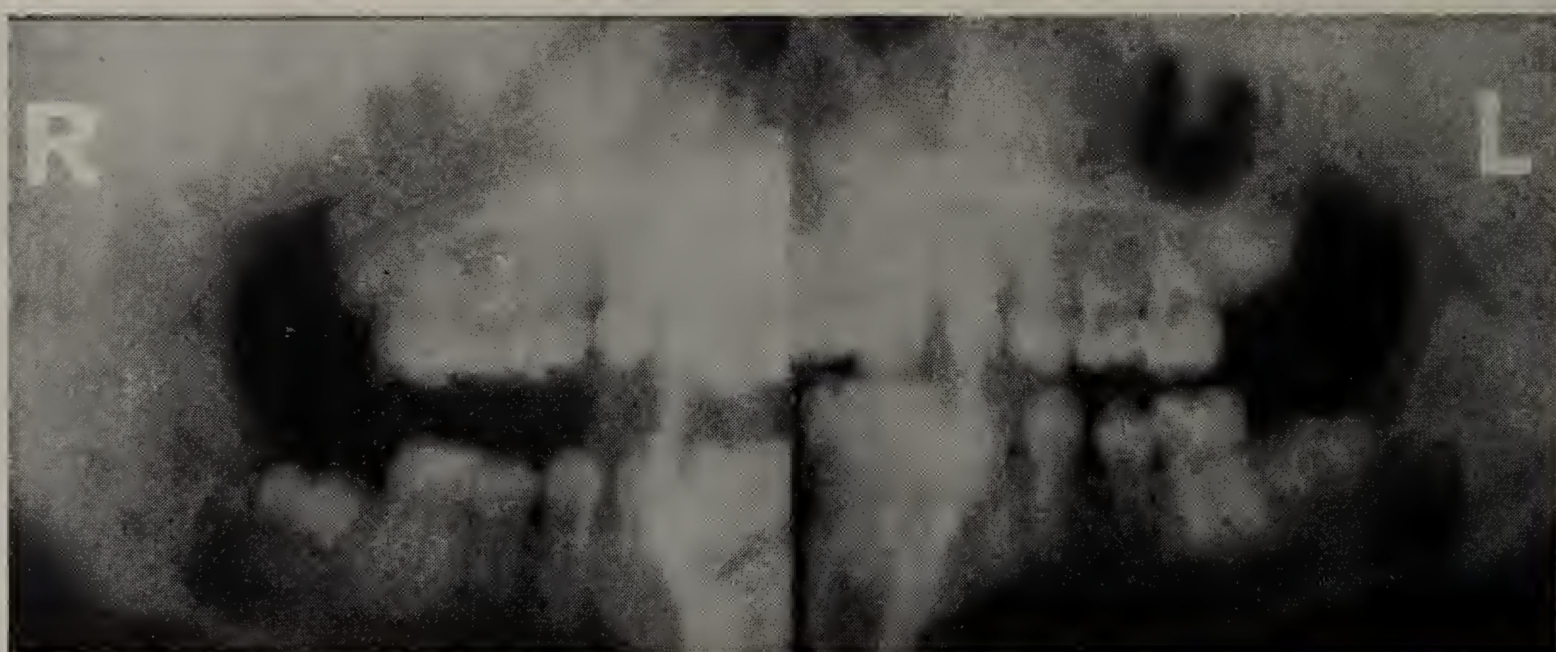
*Probability levels from tables by Smith and Penrose in Race, R., and Sanger, R. (1968), *Blood Groups in Man* 5th ed.

†Initial odds based on general physical likeness.

Table II.—Summary of Three Case Reports of Monozygotic Twins Showing a Variation in Expression of Hypodontia

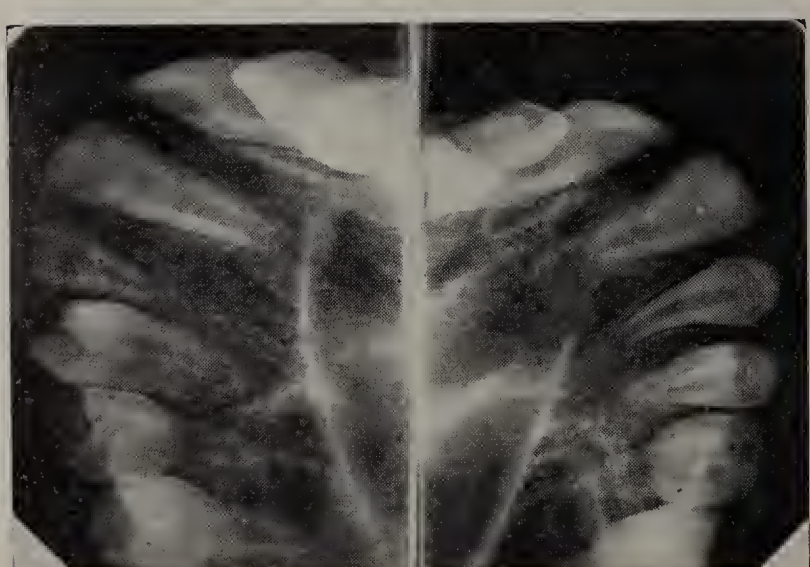
	Case 1		*Case* 2		*Case* 3	
	Carol	Jennifer	Janet	Carol	Susan	Penelope
Birth order	1	2	1	2	1	2
Birth weight	5 lb. 4 oz.	4 lb. 2 oz.	4 lb. 6 oz.	4 lb. 8½ oz.	4 lb. 4½ oz.	4 lb. 3½ oz.
Weight at time of examination	81 lb.	79 lb.	42 lb.	46 lb.	106 lb.	98 lb.
Height at time of examination	54 in.	53¾ in.	48⅜ in.	51¼ in.	63 in.	62½ in.
Missing teeth (excluding third molars)	$\frac{752 \mid 325}{1 \mid 1}$	$\frac{52 \mid 25}{1 \mid 1}$	$\frac{2 \mid 2}{5 \mid 5}$	$\frac{\mid 2}{\mid 5}$	$\frac{5 \mid 5}{5 \mid 5}$	$\frac{\mid}{5 \mid 5}$
Teeth missing in one twin only	$\underline{7 \mid 3}$	None	$\frac{2 \mid}{5 \mid}$	None	$\underline{5 \mid 5}$	None
Other dental anomalies	None	Diminutive $\underline{7 \mid}$ Additional cusp $\underline{\mid 6}$	None	Rudimentary $\underline{2 \mid}$ Retarded development $\overline{5 \mid}$	Palatal displacement $\underline{2 \mid}$ Denticle $\underline{2 \mid}$ Accessory palatal cusp $\underline{1 \mid}$	Dilaceration $\underline{2 \mid}$
Other physical anomalies	None	None	None	None	25 per cent hypoplasia of right thenar muscle No abnormality of left thenar	Absence of right thenar muscle 50 per cent hypoplasia of left thenar muscle

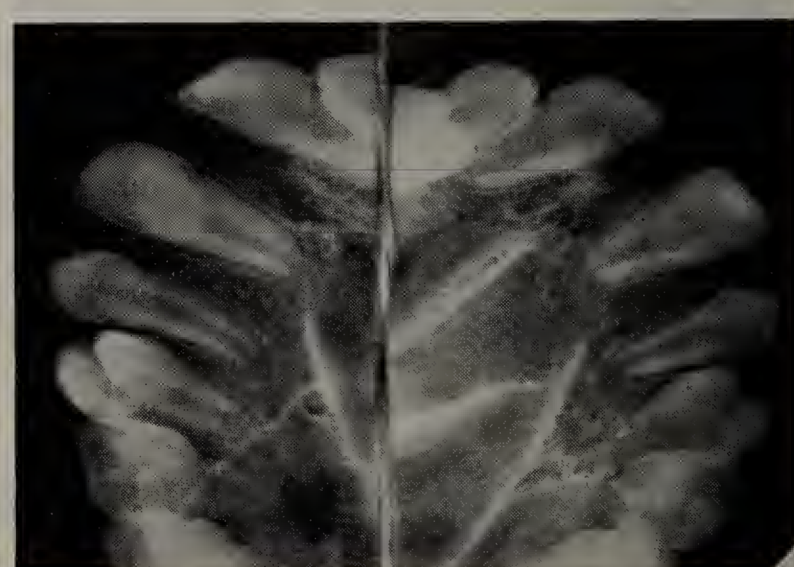
A



B

Fig. 2.—A, Carol and B, Jennifer. Oblique lateral jaw radiographs, showing absence of $\underline{7|}$ in Carol and diminutive $\underline{7|}$ in Jennifer.





A B

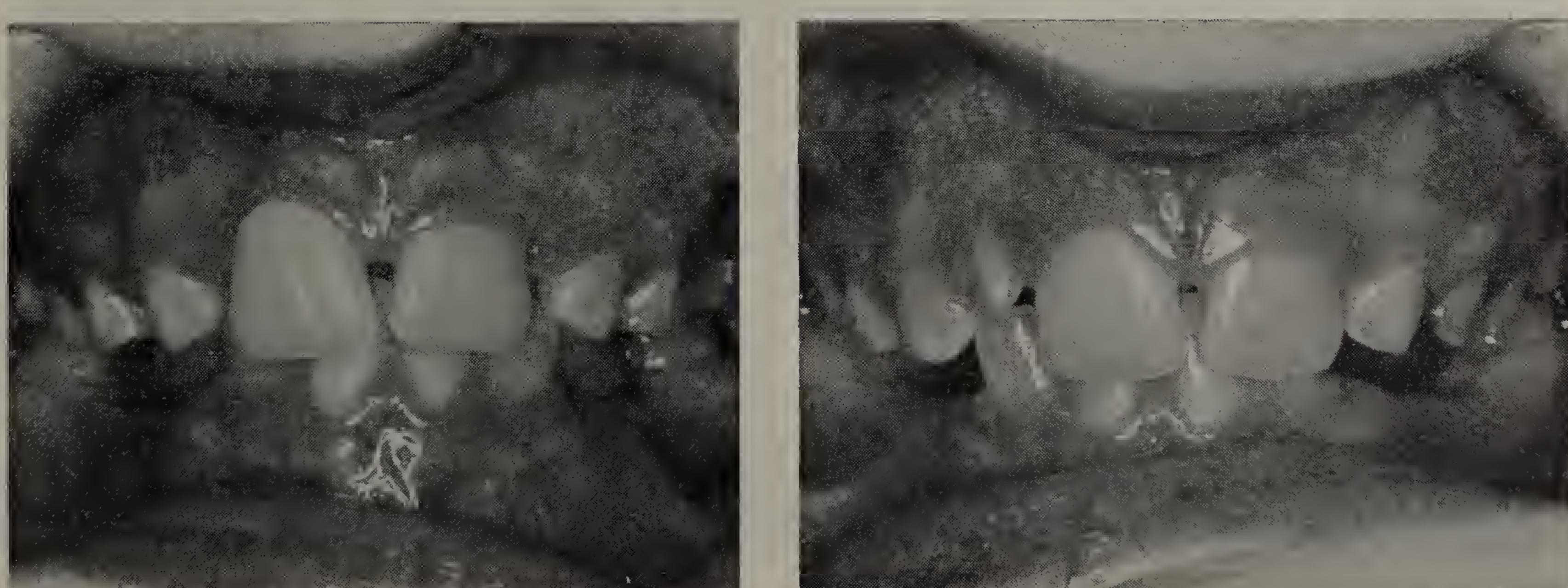
Fig. 3.—A, Carol and B, Jennifer. Occlusal films showing absence of $\underline{2|2}$ in both twins, retention of $\underline{|C}$ and absence of $\underline{|3}$ in Carol.

A B

Fig. 4.—Upper study models of A, Carol, and B, Jennifer, showing $\underline{|6}$ with four cusps in Jennifer and retained $\underline{|C}$ in Carol.

A B

Fig. 5.—Second pair of twins, A, Janet and B, Carol.

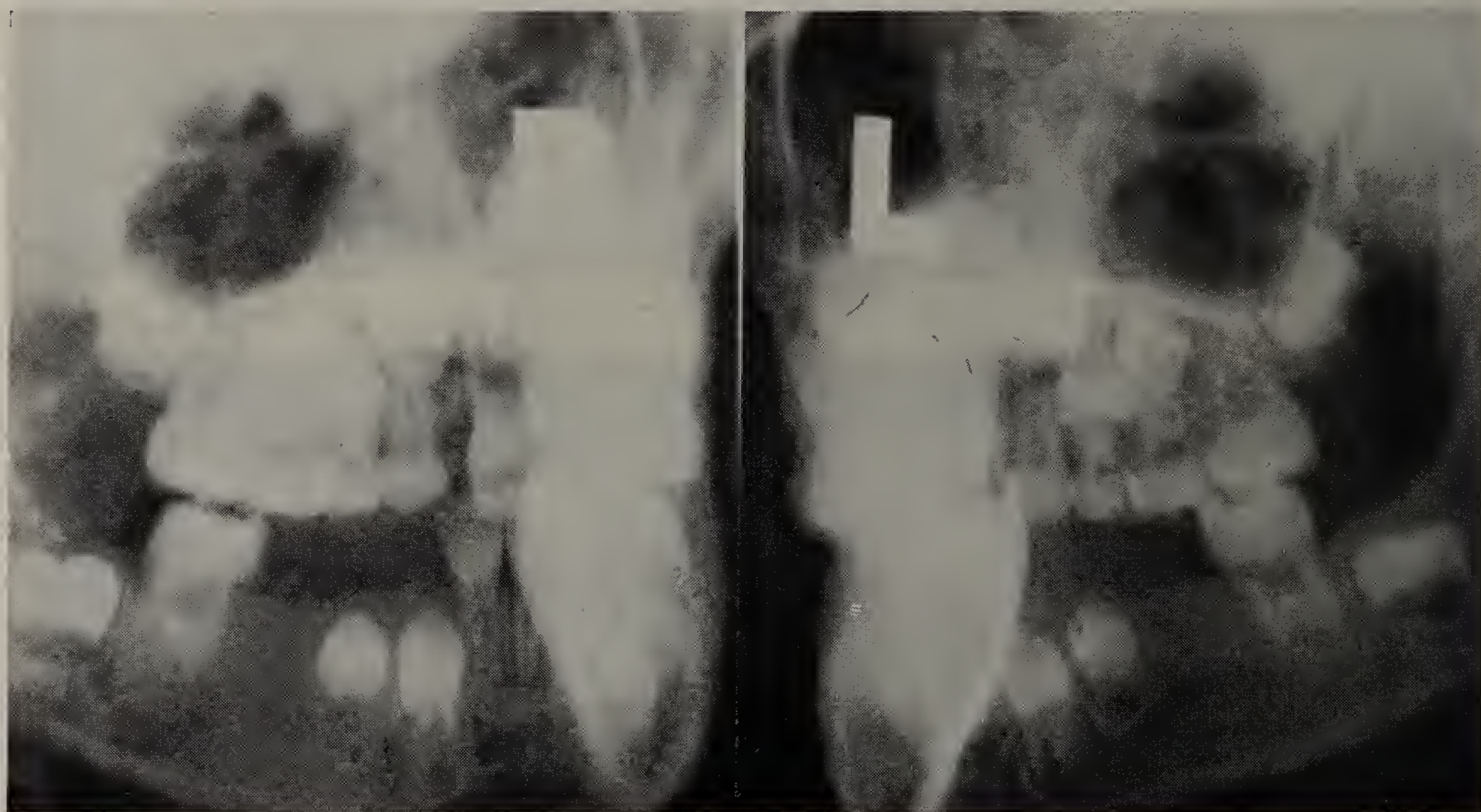


A B

Fig. 6.—A, Janet, B, Carol. Photographs showing absence of $\underline{2|2}$ in Janet and $\underline{|2}$ in Carol.

monozygosity at the 96 per cent level of probability. From these estimates, one may conclude that the likelihood of incorrectly diagnosing monozygosity on the basis of both physical likeness and concordant serological data is approximately 0·2 per cent. Kraus, Wise, and Frei (1959) have emphasized the value of examining specific features such as hair colour and texture, iris coloration, the morphology of the pinna and that of the teeth, in addition to looking for general similarity in appearance. These authors also refer to the use of testing for a concordant reaction to the taste of a weak solution of phenylthiourea.

The three case reports which follow are of twins showing concordant hypodontia with variation in the expression of the trait. The twins are believed to be monozygotic on the basis of



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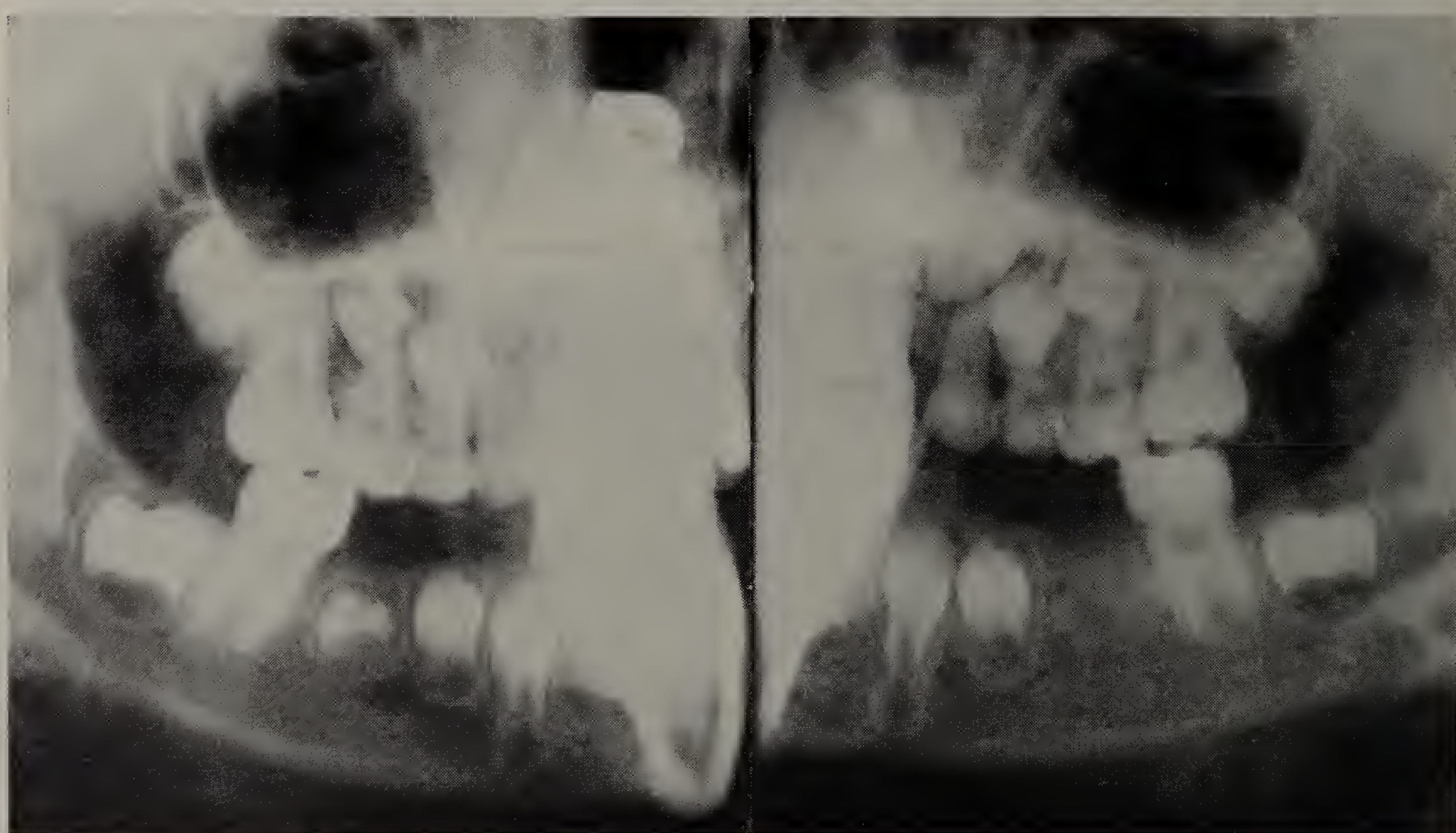


B

Fig. 7.—Oblique lateral jaw radiographs of A, Janet and B, Carol showing absence of $\overline{5}|$ in Janet only and retarded development of $\overline{5}|$ in Carol.

marked physical similarity including concordance in hair colouring and texture, coloration of iris, and morphology of the ears. They also showed a similar response to the taste of phenylthiourea. Concordance of blood groups provides further evidence of monozygosity and reduces the probability of dizygosity to less than 0·2 per cent (*Table I*).

missing teeth. On examination, Janet was found to have an Angle Class III malocclusion, the $\underline{1|1}$ being in lingual occlusion to $\overline{1|1}$, while Carol had a Class I incisor relationship. *Figs.* 6 and 7 show that both girls are missing $\frac{|2}{|5}$ and Janet also shows the absence of $\frac{2|}{5|}$, these teeth being present in Carol although $\underline{2|}$ is rudimentary and both teeth are developmentally retarded. Both girls show a dental age of approximately

A B

Fig. 8.—Third pair of twins A, Susan and B, Penelope.

Table II gives a summary of the dental and physical anomalies found on examination, together with birth orders, birth weights, and heights and weights at the time of examination.

CASE REPORTS

Case 1.—Carol and Jennifer (*Fig.* 1A, B) aged 12¼, were referred by their general dental practitioner for advice concerning the wide maxillary median diastema. There is no known history of hypodontia in the family, and subsequent examination of two younger sisters confirmed that they are unaffected by the condition.

Both twins show absence of $\frac{5\ \ 2\,|\,2\ \ 5}{1|1}$ and Carol also shows absence of $\underline{7|3}$ (*see Figs.* 2–4). The corresponding $\underline{7|}$ in Jennifer is diminutive. There are, in addition, significant variations in the morphology of the first permanent molars. In Jennifer's case, the $\underline{|6}$ has four cusps while in Carol $\underline{|6}$ is tricuspid as are the first permanent molars on the right side (*Fig.* 4).

The stage of development of the dentition in both girls is approximately 3 years behind their chronological age according to the tables compiled by Moorees, Fanning, and Hunt (1963).

Case 2.—Janet and Carol (*Fig.* 5A, B) aged 7¾ when first examined, were referred by their school dental clinic for advice about their incisor irregularity and

7 years on radiographs taken at the age of 9 years, whilst the development of $\overline{5|}$ had only reached Stage III (Moorees and others, 1963), normally found at 4¾ years (±1 year).

Case 3.—Susan and Penelope (*Fig.* 8A, B) aged 13, were referred by their general dental practitioner for advice about their absent teeth and failure of eruption of $\underline{2|}$ in Susan. *Fig.* 9 shows absence of $\overline{5|5}$ in both girls and also of $\underline{5|5}$ in the case of Susan.

Radiographic investigation showed that in Susan both crown and apex of the unerupted $\underline{2|}$ were palatally displaced (*Fig.* 10) and it was discovered that a supernumerary or denticle had been removed from between $\underline{2|}$ and $\underline{C|}$ when $\underline{C|}$ was extracted (*Fig.* 11). This was confirmed by their dental practitioner who stated that a small complete tooth was removed from this area: a periapical radiograph confirmed that this was not a retained $\underline{B|}$ root fragment. It is probably also significant that $\underline{1|}$ shows an accessory palatal cusp in Susan only. As can be seen from *Fig.* 10, the $\underline{2|}$ of Penelope also shows some palatal displacement of its apex, but this is not as marked as in Susan. Both girls show a retardation in dental development of approximately 3 years (Moorees and others, 1963).

The only other developmental abnormality found is that both twins show varying degrees of congenital hypoplasia of the thenar muscle (*Table II*), which is completely absent on Penelope's right side.

DISCUSSION

Most investigators have shown that there is a genetic predisposition to hypodontia, but the exact mode of inheritance is not clear. Grahnen (1956) stated that the most likely mechanism is an autosomal dominant gene with varying expression, possibly acting in a system involving more than one gene. Thomsen (1952) in analysing the data from Tristan de Cunha, a geographically isolated community, concluded that the trait behaves like a Mendelian recessive. Severe cases of hypodontia have been reported in the complete absence of any hereditary background (Sperber, 1963). The expression of hypodontia in kindreds shows wide variation in the extent that it can affect different members of the same family.

It is now generally accepted that congenital absence of one or more teeth cannot be considered in isolation but is firmly linked to other variables in the dentition. The relationship of absent teeth to reduction in the size of adjacent teeth is well established and Keene (1965)

A

B

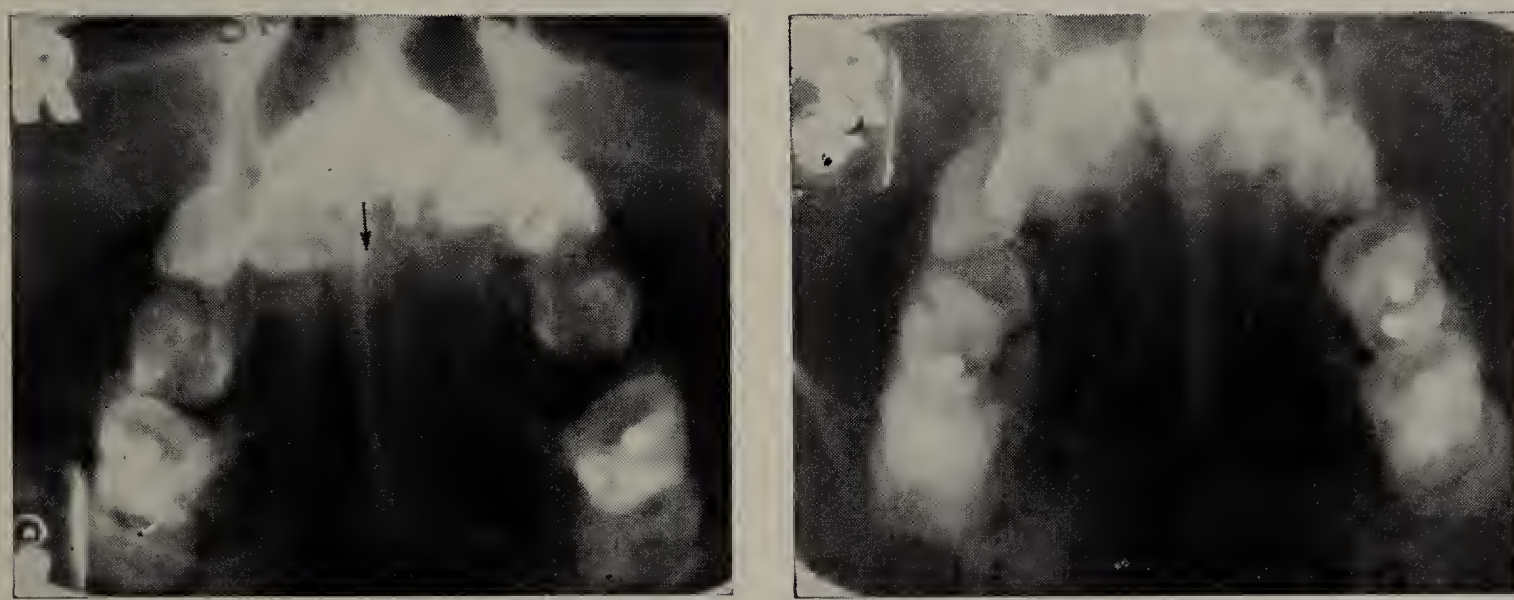
Fig. 9.—Oblique lateral jaw radiographs of A, Susan and B, Penelope showing absence of $\underline{5|5}$ in Susan only.

extended this concept to include cusp form by showing an association between reduction of the Carabelli cusp and third molar agenesis. Foster and van Roey (1970) have shown that malformed teeth are commoner in patients with a large number of missing teeth. Garn, Lewis, and Vicinus (1963) and Lind and Egermark-Eriksson (1969) have related hypodontia to the chronology of tooth development. Individuals with hypodontia may therefore exhibit not only variation in size and shape but also delay in the calcification and eruption of the remaining teeth, particularly those of the same series. Garn and others (1963) postulated that hypodontia is due to either a single gene with pleiotropic manifestations or to two independent genes.

The possibility that the maternal environment may be an influence in determining the extent and site of hypodontia has been suggested by Grüneberg (1951, 1954) and by Searle (1954a, b) who have shown that hypodontia in certain strains of mice tend to be ' bunched ' in individual litters and related to both genetic and maternal factors. Keene (1968) and Bailitt and Sung (1968) using birth weights and maternal age as indices of environmental influence have shown a correlation between these factors and hypodontia. Thus hypodontia shows a similar pattern of inheritance to congenital deformities with an hereditary element such as cleft lip and palate, or congenital dislocation of the hip (Carter, 1964).

Differences in expression of hypodontia between the left and right sides of an individual may be due to random events occurring during cell division and differentiation. If this is so, a similar mechanism would explain the variation in expression between monozygotic twins.

The concordant hypodontia recorded in the twins under discussion is consistent with the theory that hypodontia is determined genetically, but the differences which also exist illustrate the variation in its expression. The marked difference in birth weight in *Case* 1 and the congenital deformity of the hand in *Case* 3 could be regarded as evidence of an intra-uterine disturbance which might also have affected the dental development. There is, in addition, an association between birth order and degree of hypodontia in all three sets of twins but this may be coincidental.



A B

Fig. 10.—Vertex occlusal films of A, Susan and B, Penelope showing palatal displacement of $\underline{2|}$ in Susan.

Fig. 11.—Periapical film of Susan taken prior to extraction of $\underline{C|}$ showing small denticle in $\underline{2|}$ area.

The third pair are of interest in that the $\underline{2|}$ is displaced in the twin with the greatest number of absent teeth. A severe displacement of this order may be an expression of a developmental disturbance. This possibility was envisaged by one of us in a previous paper (Johnson, 1967) and

by Bass (1967), who related palatal canines to hypodontia. The literature indicates that hypodontia is a complex syndrome involving size, shape, and the rate of development of the dentition. The variations found in the reported cases support these concepts.

SUMMARY AND CONCLUSIONS

Three pairs of monozygotic twins are reported. They illustrate the variation in expression of hypodontia which can occur in monozygotic twins and they provide evidence to support the view that hypodontia is not an isolated entity but is associated with other abnormalities in the dentition, especially retardation of dental development. These cases also support the view that hypodontia is genetically determined but that its expression is affected by non-genetic factors.

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We are grateful for the help and advice received from our colleagues, especially Dr. M. D'A Crawfurd, Senior Lecturer in Medical Genetics, Leeds University, Mr. C. G. Fairpo, Lecturer in Children's Dentistry, Leeds Dental School, and Miss J. R. Kirk, Assistant Librarian in charge of the Leeds Dental School Library. We are indebted to Dr. L. A. D. Tovey and Dr. J. D. Crossland of the Regional Blood Transfusion Laboratory, for the serological data. We should like to thank the Departments of Photography and Radiology of the Royal Infirmary, Bradford, and the Photographic Department of the Dental School, Leeds, for the radiographs and photographs. We also wish to thank our colleagues for referring the cases.

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MUCOUS MEMBRANE AND DELAYED ERUPTION

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WHILST research workers in dentistry strive to understand the cause of tooth eruption the orthodontist is faced with assessing the relative significance of all those factors which might influence its course. Though abnormalities of the dental lamina are known to affect the eruption process delay can often be attributed only to variations in the anatomy of the dento-alveolar structures. Of these, factors such as tooth displacement and eruption space have been well recorded. One aspect which has received relatively little attention is the influence of the soft tissue which separates the crown of an unerupted tooth from the oral cavity.

Before active eruption can occur the tooth must penetrate the soft tissue and it is possible that in certain cases it can act as a barrier leading to superficial impaction. There is little histological evidence to substantiate whether this barrier is due to any abnormality of the soft tissue or whether a diminished eruption potential produced by other factors is more likely. It is apparent, however, that when the tooth is uncovered rapid eruption often occurs. Another possibility is the effects of variations of the normal mucosa in different regions of the jaw.

The technique of surgical exposure is practised in various sites of the oral cavity, sometimes in situations where a tooth is severely displaced. Here not only mucous membrane but adjacent bone may have to be removed to induce eruption and this gives rise to the secondary problems of the gingival margin, for the artificial gingival junction created during exposure can be at a site far removed from the position it should occupy when eruption and alinement are achieved.

There are, therefore, two main aspects in considering the role of mucous membrane in delayed eruption. The first is the influence of the soft tissue on eruption, and the second is the effects of its removal on the gingival attachment. I would like, before dealing with these, to briefly review the theories on how the erupting tooth normally penetrates the mucosa.

NORMAL ERUPTION

During development the tooth is separated from the oral cavity by both the mucous membrane and dental follicle. As migration proceeds the dental follicle unites with the connective tissue of the mucosa (Scott, 1953). Although a guiding influence such as the gubernaculum may assist the eruption process the method of tissue penetration is at present still speculative. Three possible theories are described by Provenza (1964):—

1. A shearing through the mucosa by the mechanical forces of eruption.
2. Atrophy of mucosa due to ischaemia from the pressure of eruption.
3. A breakdown of the mucosa by the chemolytic activity of enzymes.

As for the forces of eruption these have been investigated on the continuously growing rodent incisor by a number of authorities. Taylor and Butcher (1951) and Ness (1964) suggested forces between 2 and 5 g.

In a recent investigation using elastics to counter eruption Ito and Muira (1968) found that a force of 7 g. stopped the eruptive movement of the rabbit's incisor. The effects on the apical connective tissue at this pressure were only slight and though the authors considered them sufficient to causes a stasis of the microcirculation there was no evidence of tissue breakdown. In fact with forces substantially greater only an increase in the density of the connective tissue was observed.

The possibility of a breakdown of tissue by chemolysis was suggested by Orban (1962), and Fulmer (1967) in supporting this, stated that the pattern of breakdown around an erupting tooth could not be accounted for by physical forces only. He suggested that some form of enzyme activity such as that of collagenase could take place. Another possibility is epithelial proliferation; both McHugh (1961) and Melcher (1967) have shown histological evidence of this which they consider arises not only from the oral surface but also from the reduced enamel organ.

Presented at the Country Meeting held on 15 May, 1970.

The staining reaction of the overlying connective tissue led Melcher (1967) to suggest that these cells might secrete enzymes capable of chemolysing connective tissues. However, Starkey (1967) using tritiated thymidine which is incorporated into DNA synthesis could find no indications of activity in the reduced epithelium of rabbits.

A

the mucosa delays and prevents eruption whilst the association of follicular cysts with failure of eruption is well known.

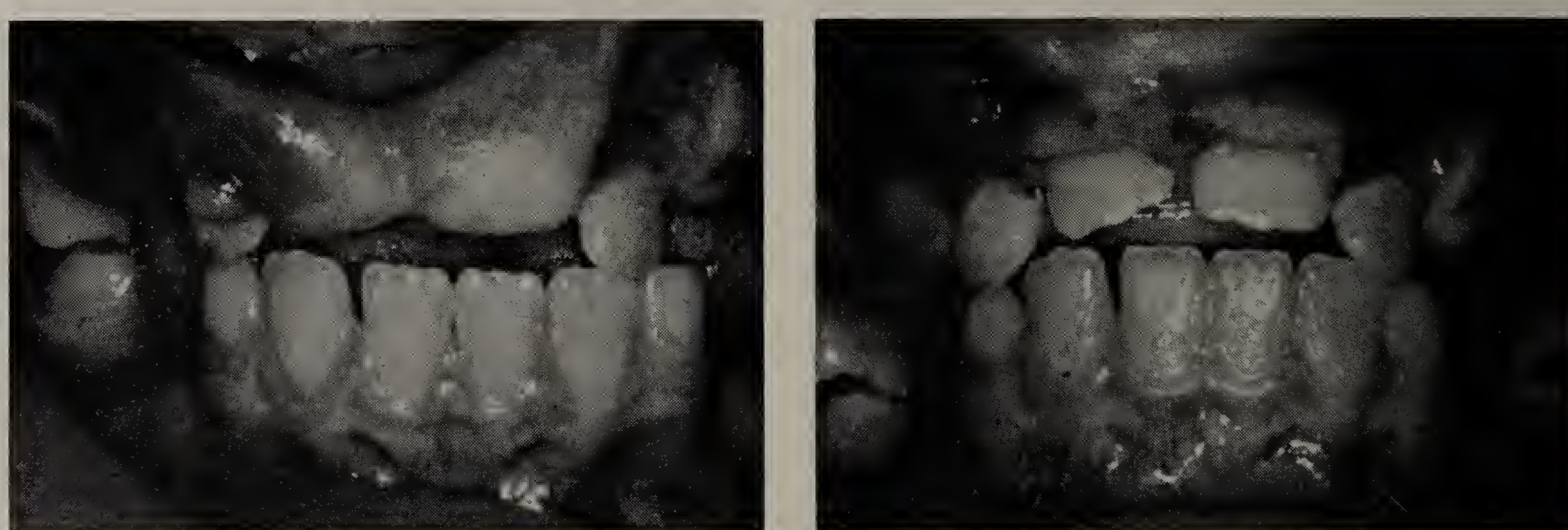
As for anatomical variations it is possible for a displaced tooth to actually miss the attached mucosa and erupt into the substance of the lip. This situation could be initiated by a lower attachment of the lip (*Fig*. 1).

Lappin (1951) considered that the denser mucosa of the palate could prevent the eruption of a palatally placed canine and it is also possible that a large fibrous fraenum could have a similar effect.

Other factors which have been associated with delayed eruption are scar tissues from trauma and surgical intervention. Burke (1954) also considered that epithelization following the loss of a primary tooth could markedly delay eruption. Whilst the loss of a primary tooth may allow reorganization of tissue over its permanent successor it is quite common to find these teeth erupting normally.

Failure of eruption also occurs when there is little obvious tooth displacement and here a tooth may become lodged superficially in the presence of adequate eruption space (*Fig*. 2). The mucosa appears to bulge over the crown and offer a direct barrier to eruption.

Stoy (1954) considered that a thickened follicle around the unerupted incisor associated with a supernumerary was more often likely to be



B C

Fig. 1.—Case of a boy aged 8½ years with central incisors in the substance of the upper lip. A, Lateral skull radiograph. B, Photograph before exposure. C, One week later.

It would seem that though the actual method of tissue breakdown is not known it is probably produced by the combined effects of both mechanical forces and chemolysis.

DELAYED ERUPTION

Pathology of both the mucous membrane and dental follicle can markedly affect eruption. In hereditary gingivo-fibromatosis an overgrowth of

responsible for its failure of eruption. Indeed, a thickening of the follicle around displaced unerupted teeth is commonly found, a factor that Kettle (1958) investigating the misplaced canine considered by no means coincidental.

Though techniques of surgical exposure may vary, if an area of mucosa is removed from over the crown of an unerupted tooth then an artificial gingival junction is created. The adverse effects of this in certain situations have been

pointed out by Broadway and Gould (1960) who noted that central incisors exposed at the time an associated supernumerary was removed were more liable, especially if labial bone were removed, to have an incomplete vertical development and a higher gingival margin. Day (1964) showed a similar case where a paradontal pocket had developed following incisor eruption. Exposure may, therefore, affect both the height and the condition of the gingival attachment.

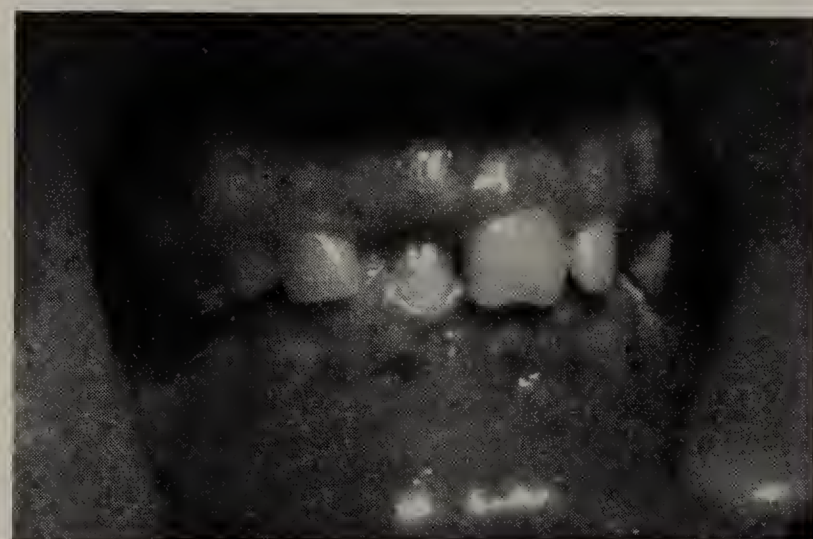
INVESTIGATION

1. Histological

To investigate the nature of mucous membrane from over the surfaces of teeth delayed in eruption, cases were selected where a tooth was separated from the oral cavity by soft tissue only and had adequate space in which to erupt.

To provide a comparative group mucous membrane was also examined from over the surfaces of normally developing teeth nearing eruption. This was obtained from cases where enucleation was part of a planned orthodontic treatment and also from post-mortem examinations. The selection of the second molar site avoided any changes in the soft tissue which might have occurred due to early loss of primary teeth. *Table I* shows the positions of teeth exposed and this was affected by surgically removing soft tissue only, just sufficient to allow the maximum width of the tooth to be uncovered.

A



B

Fig. 2.—Case of an unerupted $\underline{1|}$ lodged in the mucous membrane in a boy aged $10\frac{1}{2}$ years. A, Intra-oral radiograph. B, Photograph of $\underline{1|}$ showing tip of cusp just penetrating the mucous membrane. Eruption followed simple exposure.

Table I.—Distribution of Mucous Membrane Sections

Site of Mucous Membrane	Eruption: Delayed	Eruption: Not Abnormal
Maxillary central incisors	16*	2†
Labial canines	3	—
Palatal canines	3	—
Premolars and second molars	3	6
Total	25	8

*Five incisors showed no clinical abnormality other than slight displacement. Five were associated with very early loss of a primary predecessor. In one case previous exposure had been unsuccessful.

†Post-mortem examination.

During the operative procedure in cases with delayed eruption two definite layers were present:—

a. A superficial intact outer layer that could be incised and removed easily.

b. A deeper more fleshy fibrous layer that had to be dissected away.

The tissue was fixed in 10 per cent formol-saline and embedded in paraffin wax. Each specimen was sectioned in different planes and stained with the following:—

a. Haematoxylin and eosin for tissue structure.

b. Van Gieson's for the presence of collagen.

c. Silver impregnation for pre-collagen.

d. Periodic acid Schiff and alcian blue, histochemical stains for the presence of mucopolysaccharide.

2. The Effects of Exposure

In order to determine the effects of exposure on the gingival tissues it was necessary to examine a further series of cases where treatment of the exposed tooth had been completed for at least a year. Forty cases were selected consisting of 14 central incisors exposed labially, 21 palatally placed canines, and 5 labially placed canines.

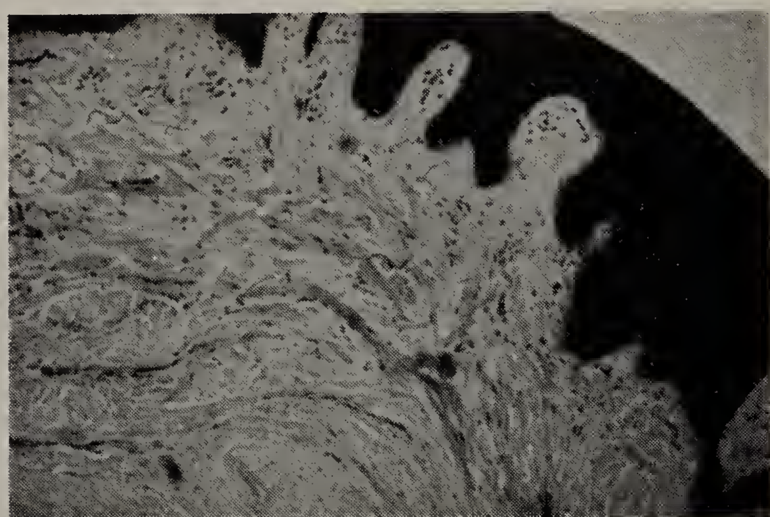


Fig. 3.—Photomicrograph of mucous membrane from over an unerupted incisor which had previously re-epithelized following exposure. Strands of denser fibrous connective tissue indicate the presence of scar tissue. H. and E. (×60.)

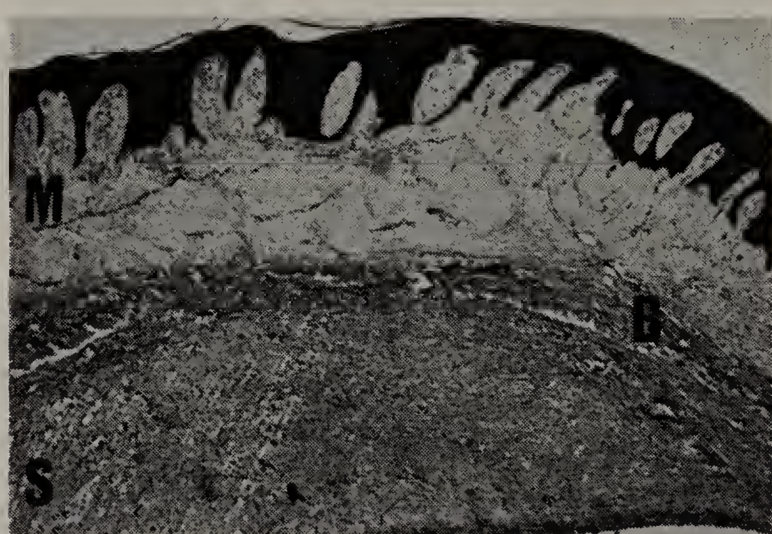


Fig. 4.—Photomicrograph of mucous membrane from over an unerupted |1 in a boy aged 10 years. M, Normal connective tissue of mucosa. B, Band of denser connective tissue. S, Immature oedematous connective tissue of submucosa over crown of |1. H. and E. (×30.)

The follow-up period after treatment ranged from 1 to 3 years and observations were made on both the height and condition of the gingival tissue during and after treatment.

RESULTS

Histological Findings

Epithelium

The oral epithelium was all of a functional stratified type with varying depths of the rete pegs and with some proliferation of the oral epithelium in certain sections. There was no evidence of any activity in the reduced enamel epithelium.

Submucosa

The thickness of this layer varied with the mature connective tissue, under the oral epithelium being more abundant in the palatal mucosa. In the section where surgery had previously occurred there was strong evidence of scar tissue in the form of patches of dense acellular collagen (*Fig.* 3).

It was in the submucosa that differences were most marked in delayed eruption. Large areas of an immature oedematous type of connective tissue were found in the submucosa over the unerupted crowns and these were often sharply demarcated from the overlying mucosa (*Figs.* 4, 5). This type of tissue was rarely seen in sections with no abnormality.

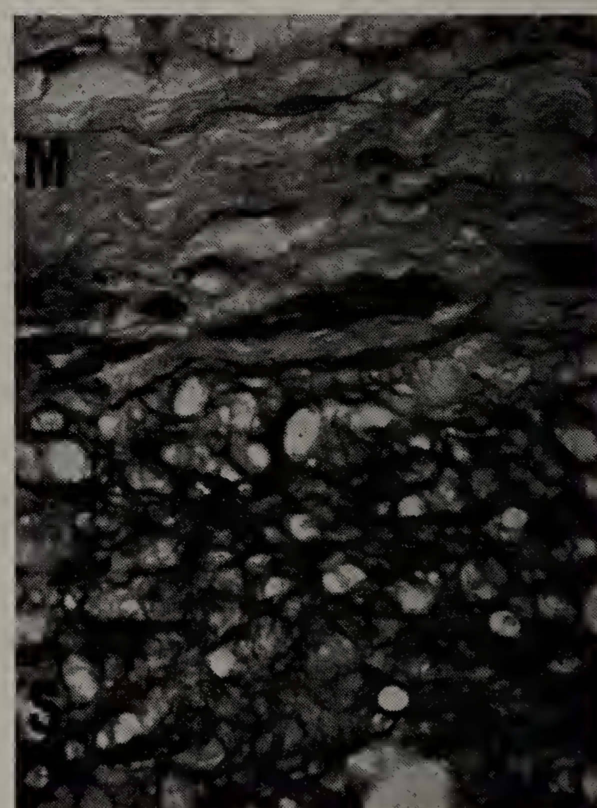


Fig. 5.—Photomicrograph of mucous membrane from an unerupted 1| in a boy aged 9 years. M, Normal connective tissue of mucosa. S, Immature oedematous connective tissue of submucosa containing mucopolysaccharide. Alcian blue and neutral fast red. (×267.)

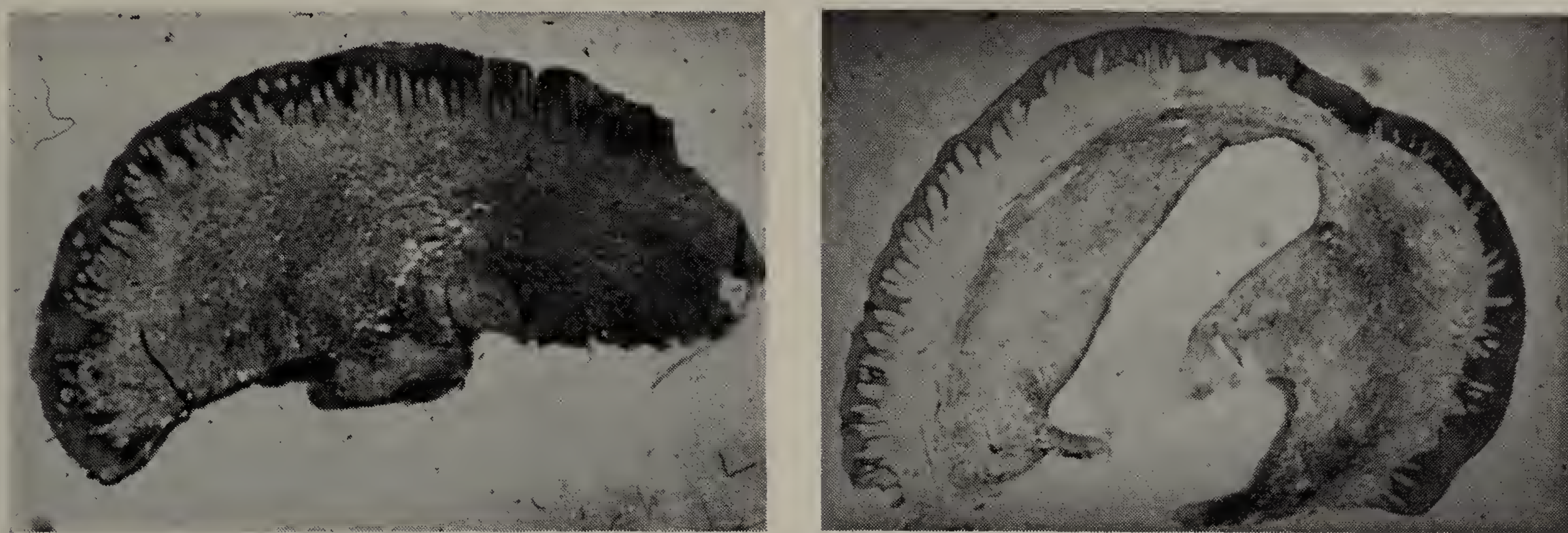
The van Gieson stain showed that the connective tissue in the submucosa was taking up picric acid rather than acid fuschin and was probably undergoing degeneration. Again this area was sharply demarcated from the mucosa in delayed eruption sections.

The appearance with histochemical stains, particularly alcian blue, disclosed the presence of mucopolysaccharides: as no precollagen could be found with silver impregnation this might indicate some form of chemolytic activity. The distribution of mucopolysaccharides was diffuse

throughout the connective tissue in the sections with no eruption abnormality whilst in delayed eruption it was localized to the submucosa with an intact overlying mucosa (*Fig.* 6).

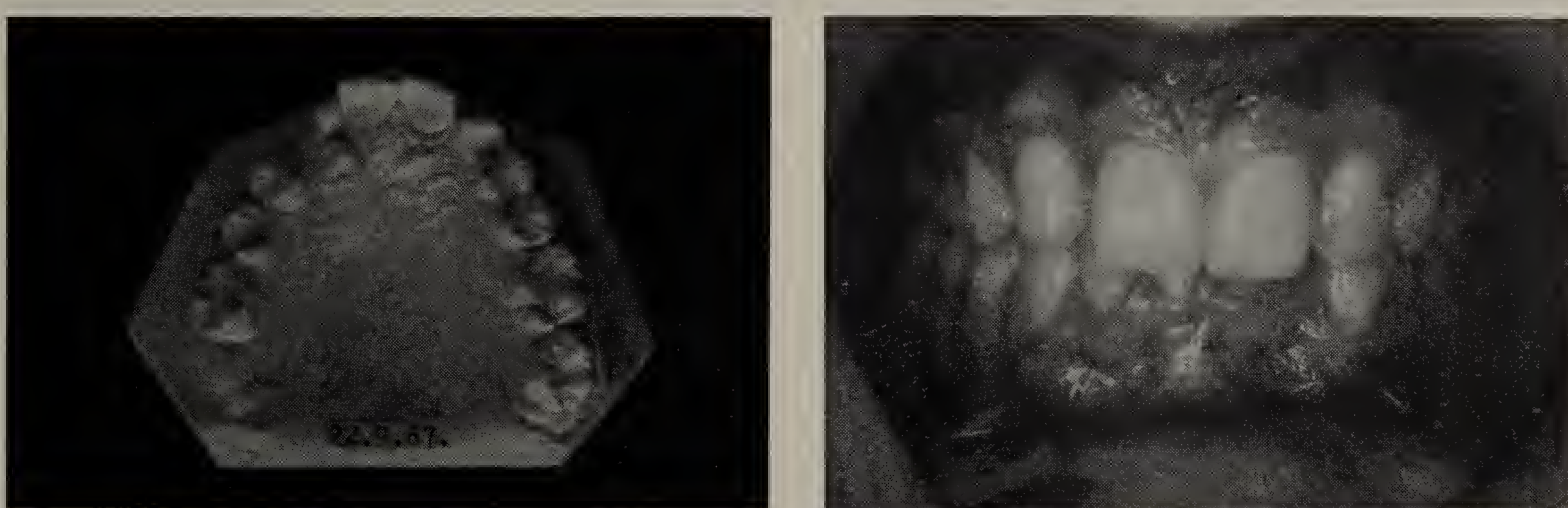
Clinical Findings

Following the removal of soft tissue over the unerupted crown spontaneous eruption occurred in all the cases shown in *Table I* except one. In



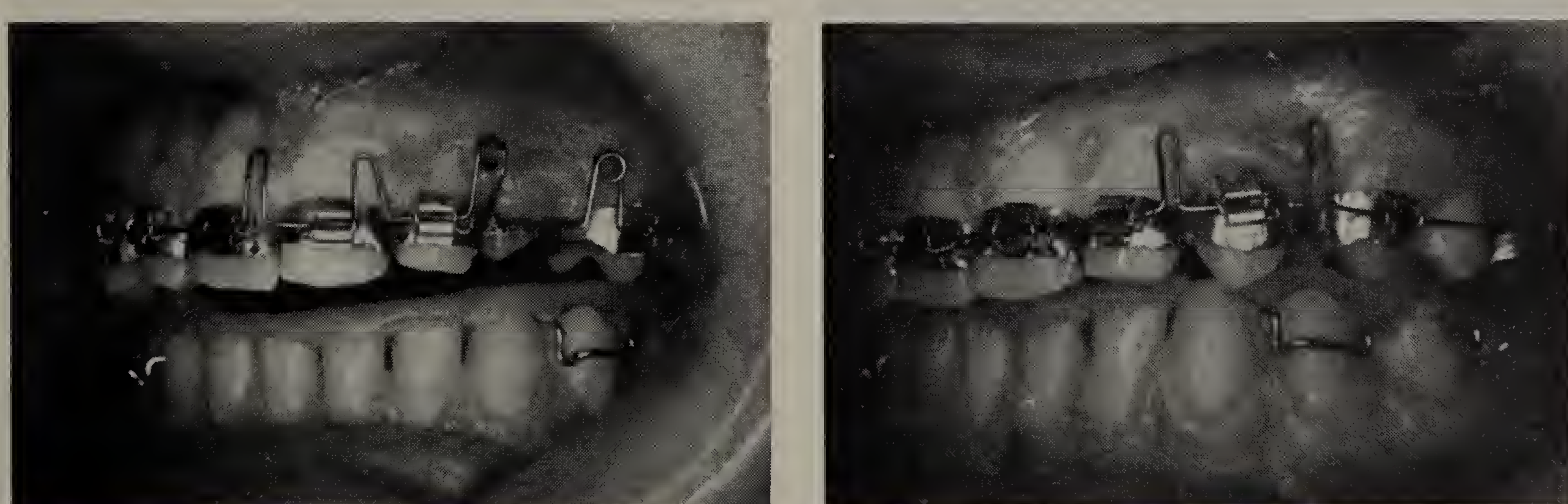
A B

Fig. 6.—Photomicrographs of sections of mucous membrane. A, From over $\overline{7}|$ nearing eruption in a girl aged 12 years. B, From over $\underline{1|}$ in a boy aged 9 years. The darker staining mucopolysaccharide is diffuse throughout the connective tissue in A whilst in B it is localized to the submucosa. Alcian blue and neutral fast red. (×15.)



A B

Fig. 7.—Case of a palatally placed canine rotated through over 90° in a girl aged 12½ years. A, Study model 6 months following exposure. B, Alinement at 15 years showing normal height and condition of gingival attachment.

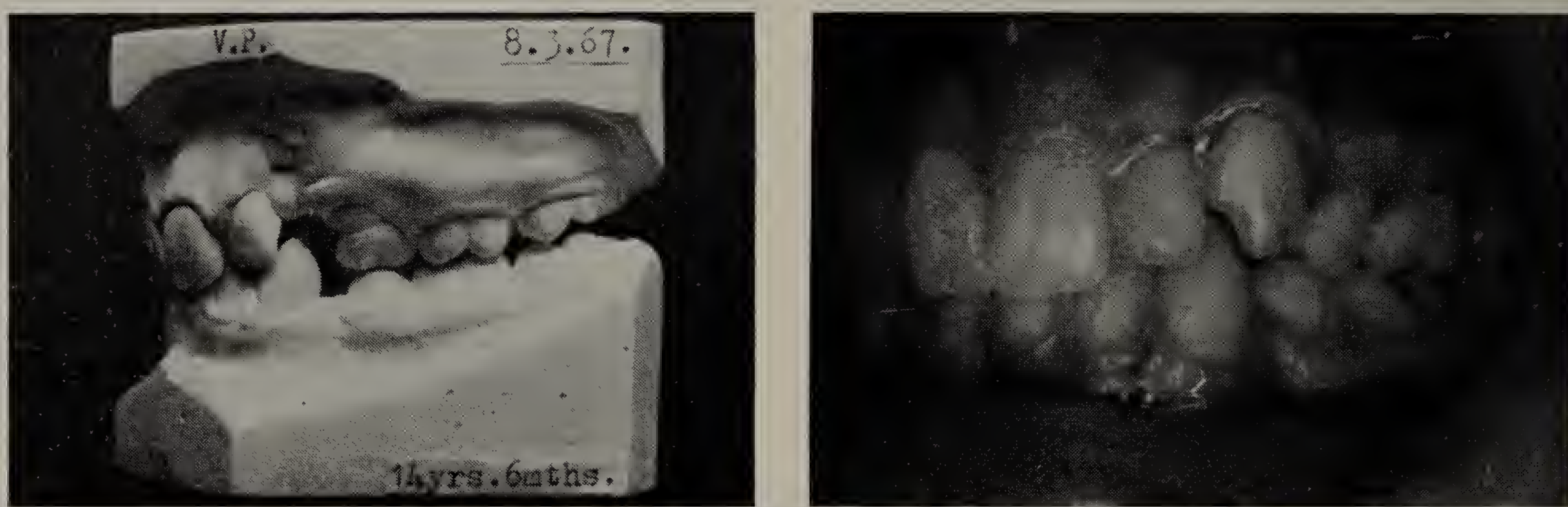


A B

Fig. 8.—Case involving movement of a palatally placed $\underline{|3}$ following exposure. A, Position of mucous membrane over $\underline{|3}$ during appliance therapy. B, The $\underline{|3}$ over the bite with a lowered and bunched gingival margin.

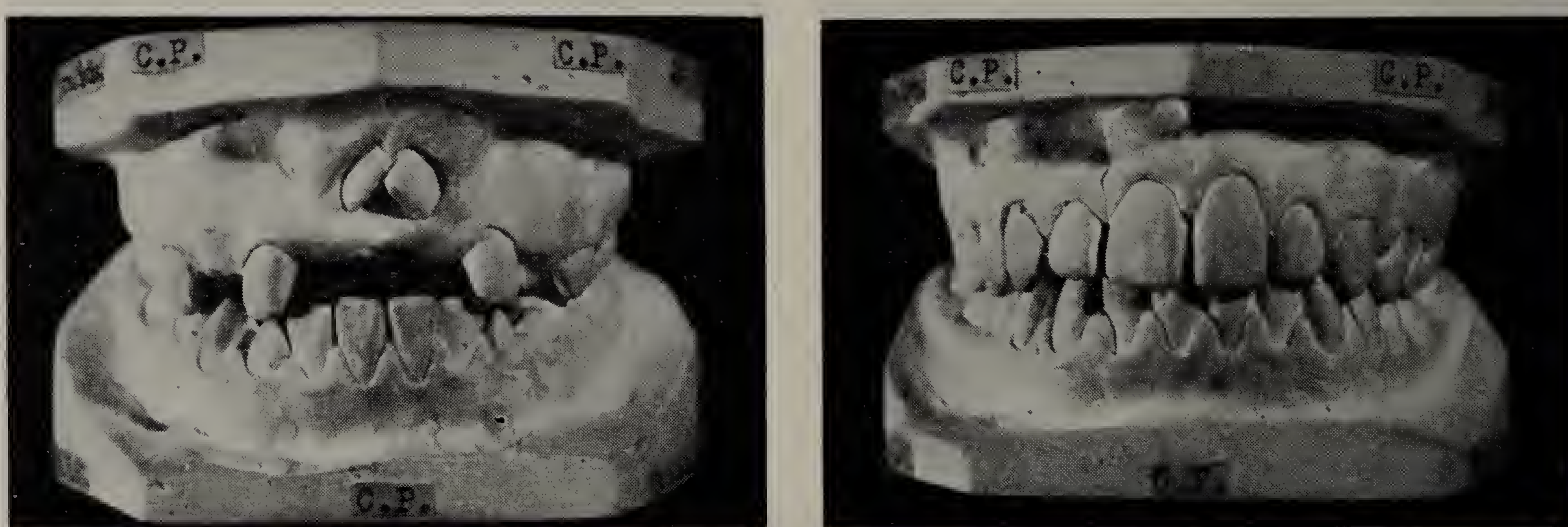
this case where there had been an earlier unsuccessful attempt at exposure, eruption eventually occurred slowly following a 2-monthly period of inactivity.

It was rarely necessary to use a pack on the labial aspect of the alveolus but palatally over the unerupted canine it was used routinely for a



A B

Fig. 9.—Case where a canine was exposed labially in a girl aged $14\frac{1}{2}$ years. A, Study model 2 weeks after exposure and pinning. B, Alinement at 17 years, 2 years after therapy, showing incomplete vertical development of |3 and higher gingival margin.



A B

C

Fig. 10.—Case where the central incisors were exposed above the mucogingival junction following removal of associated supernumeraries. A, Study models 3 months after exposure. B, Position after appliance therapy with elongated crowns and enlarged gingival cuffs over $\underline{1|1}$. C, The appliance.

3-week period due to the rapid regranulation rate of the mucous membrane.

Height of Gingival Margin

Neither the removal of the palatal mucous membrane nor the removal of adjacent bone had any marked adverse effect on the height of the gingival margin following full eruption (*Fig.* 7).

One feature noted was a lowering and bunching of the gingiva on the labial aspect of the tooth during appliance therapy (*Fig.* 8). This was probably due to the mucous membrane on the alveolar crest being at a lower level and it tended to improve spontaneously once appliance therapy had been completed.

On the labial aspect a higher gingival margin was found particularly when mucous membrane was removed above the mucogingival junction. Whilst this was often acceptable over a canine (*Fig.* 9), it left an unsightly appearance over the central incisors especially in the unilateral case where the exposed incisor had a considerably longer clinical crown (*Figs.* 10, 11).

Condition of Gingival Attachment

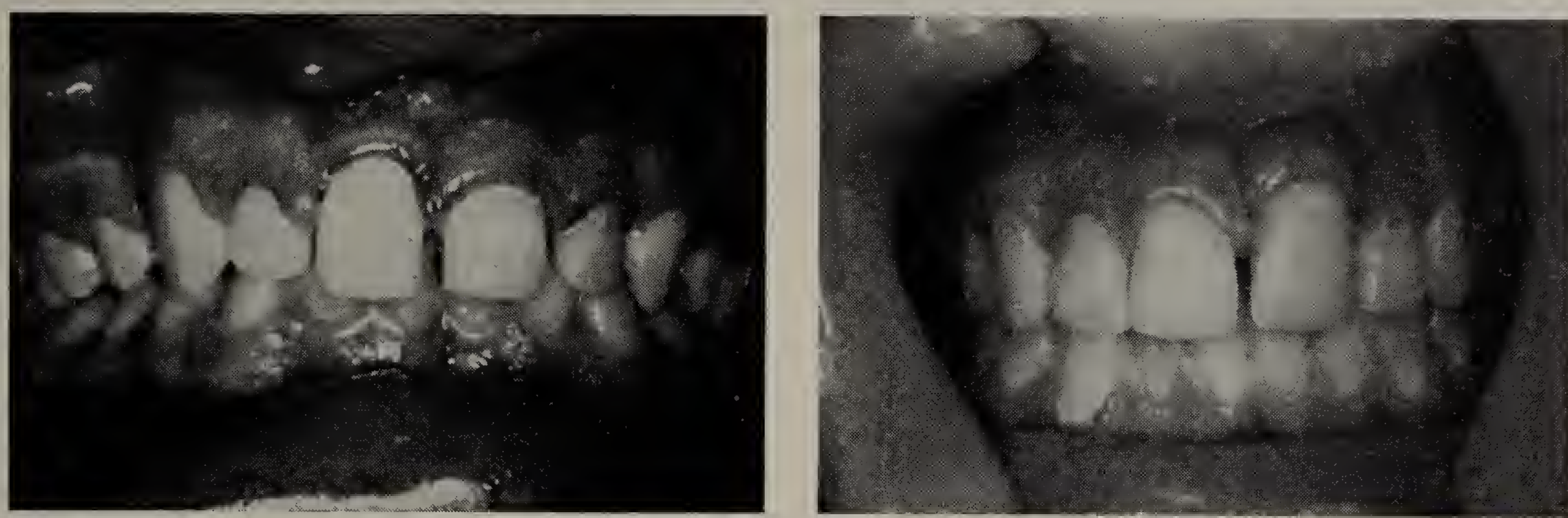
As with the gingival height little adverse effect was observed on the condition of the gingival attachment following the removal of palatal mucous membrane (*see Fig*. 7). On the labial aspect, however, where non-functional mucous membrane was removed above the mucogingival junction there was a tendency for the gingiva on the affected tooth to have an enlarged and festooned cuff (*Fig*. 11). This appeared also to lack the normal keratinization of the surrounding gingivae and seemed more prone to later paradontal disease.

DISCUSSION

Though it is apparent that in most sections chemolysis may occur the lack of activity of the reduced enamel epithelium would support the view that it plays little part in the penetration process. There is also no indication that re-epithelization after the loss of a primary tooth has any marked effect on tissue breakdown but it may, in the presence of other factors, become an additional barrier.

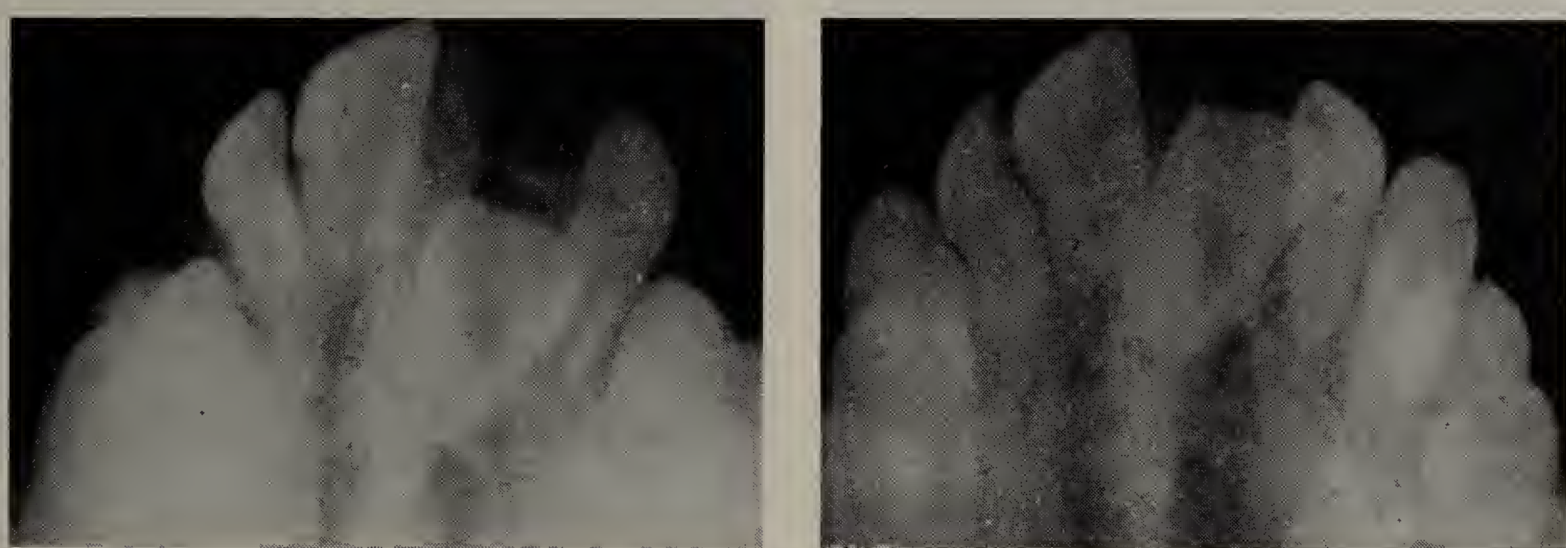
The differences in the connective tissue in delayed eruption sections are interesting for they suggest that though a breakdown is occurring around the tooth it is not affecting the overlying mucosa. The sharp demarcation between the two layers is evidence that a barrier is probably present rather than just a slowing of the normal process, and in some sections a separate fibrous band could be seen at this junction (*see Fig*. 4).

In interpreting these findings it is recalled that during migration an unerupted tooth is often accompanied by an enlarged follicle which is readily seen on a radiograph. As the tooth becomes more superficial the follicle may not be seen due to surrounding soft tissue (*Fig*. 12). If an enlarged follicle should remain it is evident that the tooth must penetrate both this and the mucosa before active eruption can occur. Also



A B

Fig. 11.—Condition of the gingivae following exposure above the mucogingival junction. A, A boy of 17 years with an enlarged inflamed gingival cuff 1|. B, A boy of 15 years with a long clinical crown and paradontal pocket |1.



A B

Fig. 12.—Occlusal radiographs of a boy with an unerupted |1. A, At 10 years, showing an enlarged follicle. B, At 11½ years, just before exposure where |1 is superficial and the follicle is not apparent. (Section of the mucosa is shown in *Fig*. 5.)

any failure of the outer surface of the follicle to unite with the mucosa will entail a delay in the breakdown of the mucosa and so constitute a further barrier to eruption. The histological picture seen in sections would support this. Therefore it would appear that the dental follicle rather than the mucous membrane is more likely to provide a barrier to eruption. In certain instances, however, the mucous membrane can cause delay and this occurs in cases where there is either hyperplasia of the connective tissue or where there is dense acellular collagen as seen in ' scar tissue ' (*Figs.* 3, 13).

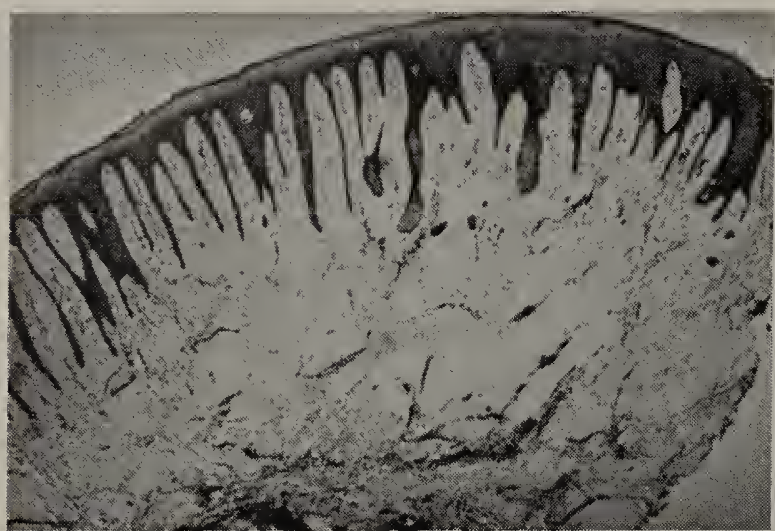
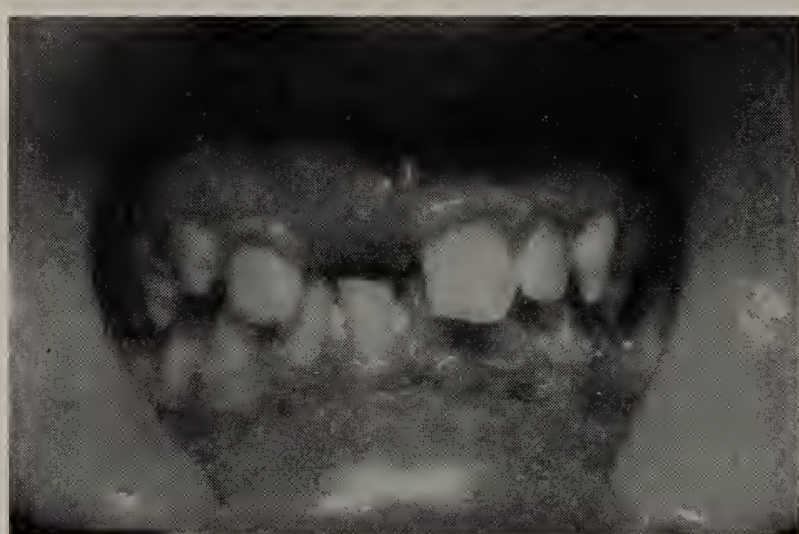


Fig. 13.—Photomicrograph of mucous membrane from the labial aspects of an unerupted 3| in a boy aged 11 years with gingival fibromatosis. Hyperplastic connective tissue of the mucosa and enlarged rete pegs of keratinized oral epithelium are visible. (×30.)

Adverse affects on both the height and condition of the gingival attachment appears to occur only in those cases where exposure is effected on non-functional mucosa above the mucogingival junction on the labial aspect of the alveolus. This could be related not only to the greater height of exposure, but also to the nature of the artificial junction created, for, if a normal attachment is to be obtained during eruption, this tissue must change from the non-functional character of the unattached mucous membrane to the functional character of normal attached gingivae. Whilst this would appear to happen to a large extent it is evident from the enlarged gingival cuff seen, that in certain cases, it retained some of the qualities of the original tissue.

It is not intended to discuss the merits of the various techniques used in surgical exposure for these must depend upon the significance of each factor involved. However, it would seem preferable where possible to avoid exposing the tooth above the mucogingival junction. More superficially simple exposure on the functional mucosa often hastens eruption by removing barriers suggested earlier and without adverse effect on the gingival margin (*Fig.* 14).



A

B

C

Fig. 14.—Case of a boy aged 10½ years with failure of 1| to erupt following earlier loss of an associated supernumerary. A, The 1| lodged superficially on the labial aspect of the alveolus. B, One month after simple exposure. C, Position 2 years later following spontaneous eruption with normal gingival height and condition.

One final point on the subject of the unerupted incisor associated with a supernumerary. In a recent survey Di Biase (1971) found that 75 per cent of incisors erupted spontaneously after removal of the supernumerary. Thus it would appear in this condition there is often very little neeed for exposure particularly at the time the supernumerary is removed.

SUMMARY

The role of mucous membrane as a contributory factor in delayed eruption was investigated together with the effects of surgical exposure on the gingival tissue.

Mucous membrane was examined histologically from over the surface of 33 superficially placed teeth erupting both normally and delayed in eruption.

Sections showed that tissue breakdown was occurring in all cases but whereas this was diffuse throughout the connective tissue in cases with no eruption abnormality, in delayed eruption it was localized to the submucosa and sharply demarcated from the overlying intact mucosa.

In conjunction with radiographic evidence it is suggested that the remnants of an enlarged dental follicle rather than mucous membrane were more likely to cause delay in tooth eruption. Only when there was either hyperplasia or scar tissue did the mucosa appear to offer a direct barrier.

An examination of 40 further cases where mucous membrane had been removed to induce tooth eruption was undertaken to determine the effects of exposure on the height and condition of the gingival attachment.

There was no evidence to show that the removal of palatal mucous membrane had any adverse effect on the height or condition of the gingival attachment following eruption and alinement. On the labial aspect the removal of non-functional mucous membrane above the muco-gingival junction gave rise to a long clinical crown and higher enlarged gingival attachment. This tissue was often less keratinized than the surrounding gingivae and appeared more prone to later paradontal disease.

The removal of functional mucous membrane superficially in delayed eruption usually hastened eruption without any adverse effect on the gingival tissue.

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Finally, I am indebted to the Board of Governors at The London Hospital for their research grant in connexion with this project.

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DISCUSSION

Dr. J. R. E. Mills said that the paper had been a very interesting one. It seemed strange that so very often when supernumerary teeth were removed to allow incisors to erupt (his own practice was not to expose the crown) the crown moved down until the outline could be seen through the mucosa, as shown here. If one waited long enough it would erupt but it would take 2 or 3 years. If one uncovered it, it erupted very quickly. The histological evidence would seem to explain why this was so. Could Mr. Di Biase say why this histological picture should present in these cases? Was it simply scar tissue resulting from the removal of the supernumerary or was there more to it? He wondered why Mr. Di Biase exposed the teeth when they were high in the labial sulcus. Dr. Mills felt that it was very seldom necessary to move the teeth down incisally. He could only think of two or three that had stuck and not come down. Mr. Di Biase had mentioned 7 grammes as a force. If these teeth had to be pulled down it could be done very gently with a latex elastic very slightly stretched or a very gentle spring. This possibly helped to minimize the untoward features.

Then there was the incisor that would not come down quite all the way. This was apt to occur if the tooth was exposed surgically, particularly if it were very brutally exposed, but it occurred sometimes when the tooth was not exposed. He had seen cases where they had been brought down and had gone back?

Mr. Di Biase thanked Dr. Mills for his comments but doubted whether he was able to supply all the answers. One of the difficulties in investigations of this type was that there were always limitations with

regard to the knowledge of tissue metabolism, particularly collagen breakdown. Though considerable research had been undertaken on the subject it was far from fully understood. Regarding scar tissue, when a supernumerary was removed the incision was usually made around the gingival crevice; he had found no evidence of scar tissue in these cases if the incisor had subsequently been exposed. It was only in cases where exposure had been affected at the time of operation and re-epithelization had occurred that scar tissue was evident. The point he had tried to make about the unerupted tooth superficially placed was that the remnants of an enlarged dental follicle might be responsible for the delayed eruption and though there were indications of degeneration in this tissue it was not accompanied by a breakdown of the overlying mucosa.

As to why he had exposed teeth in a high situation he would be inclined particularly in the incisor region to allow as much spontaneous improvement as possible. However, as there were many factors involved, particularly the degree of displacement, in some cases there seemed little alternative to exposure when the tooth failed after a considerable period to erupt spontaneously.

Mr. G. C. Dickson referring to Dr. Mill's last point, said that it was one that many of them had thought about. He put forward a hypothesis and invited the speaker's comments.

Yesterday they had been talking about the free gingival and trans-septal fibres of the periodontal membranes. These are formed as the tooth reaches its final position. When a tooth was delayed in eruption and had stopped before this was complete, it might be that those trans-septal or free gingival fibres formed after the tooth broke through the alveolar bone were sufficient to prevent the last millimetre or so of eruption.

Mr. Di Biase thought that the recent work of Thomas (1967) (*J. dent. Res.*, **44,** 1159) would tend to support this view. For if the collagen contents of the periodontal membrane were an important part of the eruption mechanism then any premature maturation of these fibres could obviously affect the final occlusal level of an erupting tooth.

Mr. A. J. Walpole Day said that his own observations on this were that the early diagnosis was one of the important things. If at 7 years of age one could diagnose and expose incisors likely to remain unerupted, the central incisor would certainly erupt its full length. For every year of delay after that the incisor seemed to erupt less and less.

Mr. Di Biase said he agreed that timing was an important factor but would prefer to leave this point until he had presented further evidence to the Society.

Mr. H. E. Wilson said that the speaker seemed to infer that the gingival cuff was abnormal; it was a variation of normal. It could be observed in normal erupting teeth. When two teeth were erupting more or less at the same pace one could find quite a large cleft between the gingival cuffs. At this stage it looked abnormal but later it became normal in appearance and texture. He did not think this gingival cuff could be considered as an abnormality.

Mr. Di Biase agreed that an enlargement of the gingival cuff seen over the erupting tooth was not abnormal. However, the gingival margin in cases where a tooth had fully erupted following exposure had been compared with adjacent gingivae and he was suggesting that the mucosa in this situation had not fully completed its transformation to the functional type. He felt that this tissue was more liable to paradontal disease, particularly in patients prone to gingivitis.

Mr. F. J. MacCauley, referring to the gingival level over some exposed incisors, asked whether this could be related to the underlying bone. If the teeth were exposed early rather than later there could be some residual alveolar growth which would produce labial bone to support a gingival level comparable with adjacent teeth which had erupted normally.

Mr. Di Biase said that most orthodontists would probably prefer to allow for spontaneous eruption in such cases. It was a matter of removing the supernumerary, creating sufficient space, and then continuing observations. Perhaps if a little more were known about the effects of variations in anatomical features then one could be more accurate in assessment. It could then be said with greater confidence which teeth would erupt spontaneously and which teeth would require exposure. He agreed that the removal of labial bone was an important factor but was not sure about the relative merits of earlier removal. However, he did feel that together with the removal of mucous membrane this could if undertaken later give rise to a long clinical crown and poor gingival attachment.

Mr. G. F. Taylor asked whether the speaker noticed any difference in the behaviour of the eruption of the central incisors following the removal of the different types of supernumerary found in this region.

Mr. Di Biase said that the eruption of central incisors following the removal of a supernumerary was very varied. Though associated with the type of supernumerary he felt it was caused by variations in the anatomical features of the unerupted incisor. The longer periods of incisor eruption found with a later developing tuberculate type of supernumerary were probably due to the greater degree of central incisor displacement.

AUTOGENOUS TRANSPLANTATION OF UNERUPTED MAXILLARY CANINES: A CLINICAL AND HISTOLOGICAL INVESTIGATION OVER FIVE YEARS

Dr. K. E. THONNER,

Head of Orthodontic Department, County Council of Stockholm

INTRODUCTION

I regard it as a great honour to have been invited to participate in this Congress of the British Society for the Study of Orthodontics at Brighton and, of course, I am most pleased at the interest you have displayed in my studies on the autogenous transplantation of impacted canines. The experience I gained in the course of the 5½ years covered by this investigation has, I feel, led to the recognition that the autotransplantation method, has a place in our combined orthodontic and surgical treatment. It remains now to see whether my account will convince this highly qualified audience.

In an article entitled ' The Role of the Permanent Canines in the Race for Space ', published in 1962 in the *American Journal of Orthodontics*, Dr. Lane points to the importance of the canines —both functionally and aesthetically. He says: ' Probably the greatest tribute paid to the importance of the permanent canines is the endless number of hours that orthodontists spend either devising a means to bring an impacted canine into occlusion, or anxiously waiting to see the results of the attempt .' While this might sound somewhat dramatic, experience shows that the treatment of impacted canines that deviate greatly from the normal path of eruption can well present major problems with conventional methods of treatment. The treatment time will not infrequently be extremely long, and even then the outcome may be doubtful. The purpose of the study I shall outline was to ascertain whether by autogenous transplantation it might be possible to shorten the treatment time and also to extend the range of indications for this form of therapy. We began the study at my department in 1964. During a holiday in Great Britain in 1967 I had the opportunity of reporting a preliminary study of the method at the Universities of Sheffield and Liverpool. An article on the study has recently been published (Thonner and Meijer, 1969). In view of this I shall limit my lecture to a closer look at details that proved to be of particular significance when the study was completed.

HISTOLOGICAL STUDIES

It was found that even in the case of severely impacted teeth the periodontal membrane can be retained during the extraction and that, by preserving the tooth in blood-serum, its vitality can be maintained during the critical interval between its extraction and its insertion in the new socket. This is evident from two histological specimens. The first specimen (*Fig.* 1) is from the surface of the root just after extraction. The cementum can be seen, and contiguous with it, well-vascularized periodontal tissue. The next specimen (*Fig.* 2) was taken after the tooth has been preserved in blood-serum for an hour. It is evident that the tissues still stain well.

The study also showed that our earlier view on the reaction of the pulp in the case of interrupted nutrition of this type is due for revision. The pulp tissue has displayed a strong resistance and, under favourable conditions, some regenerative capacity. In the histological specimen shown in *Fig.* 3 which is from a pulp removed 6 months after the transplantation, we find an almost normal pulp tissue. *Fig.* 4 shows part of a pulp removed 3 years after the operation, and here too there are well-stained cells. In both cases local anaesthesia had to be administered before the pulps could be removed.

In *Fig.* 5 on the other hand, we find that the pulp tissue shows degeneration with extensive calcification. In this case the pulp was extirpated 3½ years after the transplantation because the patient complained of sensitivity to cold. There

Twenty-fourth Northcroft Memorial Lecture presented at the Country Meeting held on 15 May, 1970.

was, however, no sign of inflammation in the pulp and a culture test showed the root canal to be sterile. In this connexion I would refer to a remark made by Professor Hodson in Sheffield in 1967 to the effect that the histological pictures which I showed on that occasion possibly indicated necrotic changes. He said that he would, however, consider that even if the pulp were non-vital, so long as it was sterile it would fulfil the same purpose as a proprietary root filling. This comment prompted me to perform culture tests of the root canal in subsequent cases of pulp extirpation. I have always found them to be sterile.

Fig. 1.—Histological appearance of periodontal tissue adhering to an impacted canine after removal. A, Cementum, B, Cementoblast layer. C, Periodontal membrane.

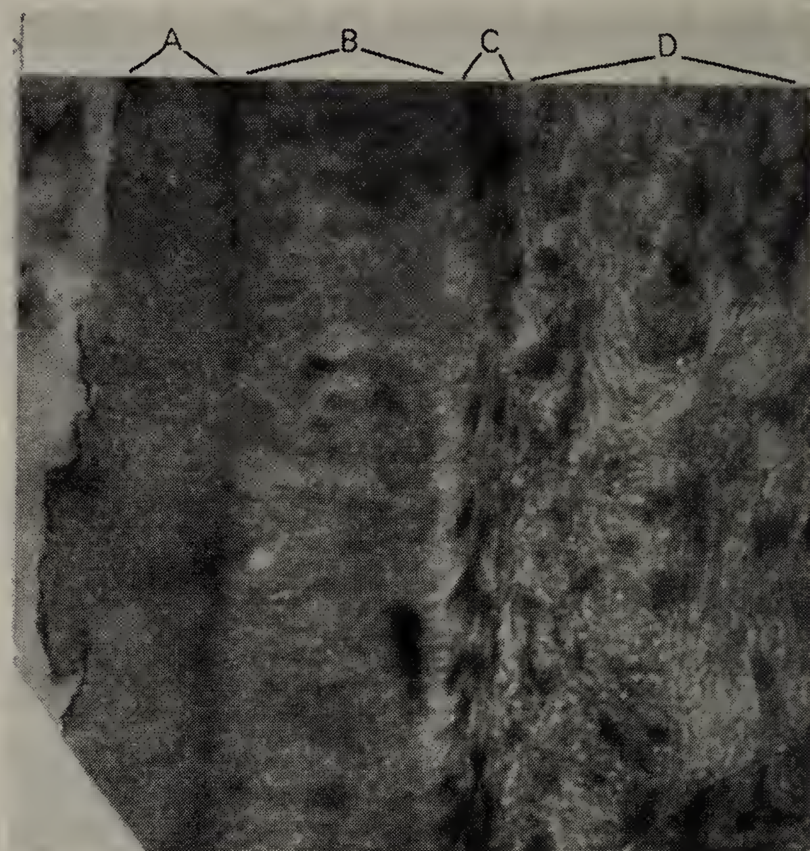


Fig. 2.—Root surface 1 hour after extraction and immersion in serum. A, Dentine. B, Cementum. C, Cementoblast layer. D, Periodontal membrane.

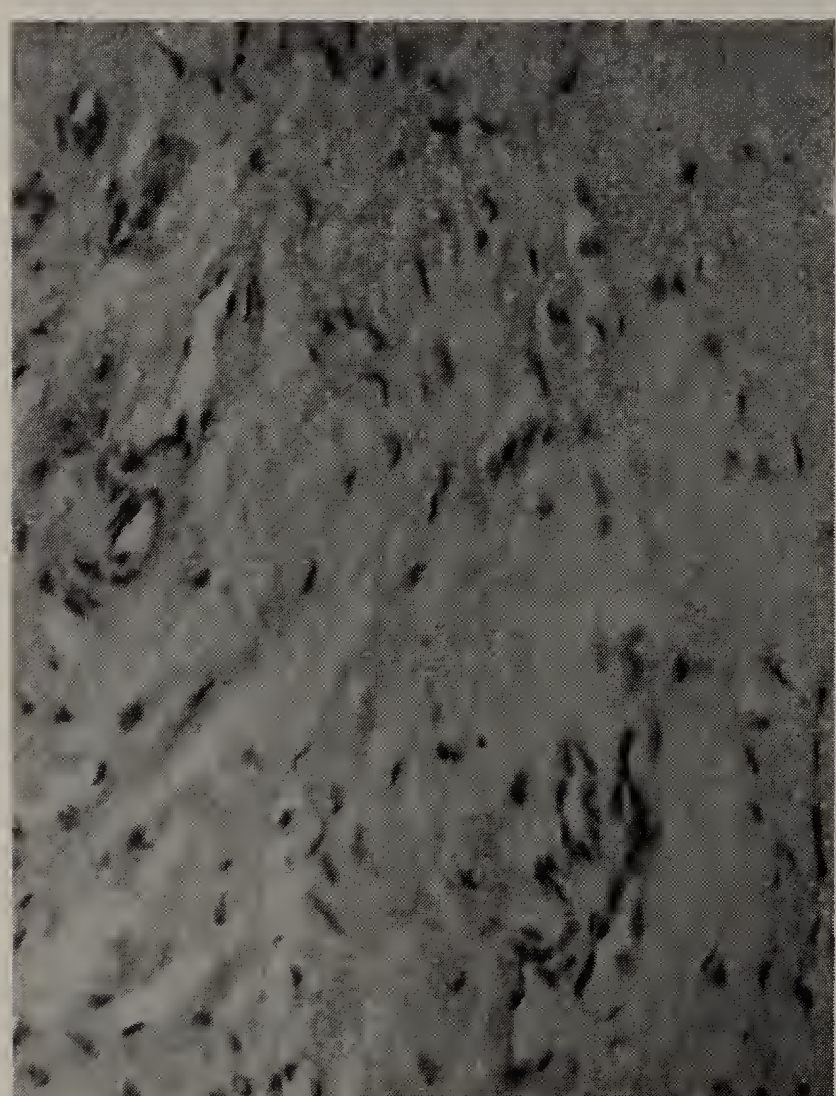


Fig. 3.—Histological appearance of pulp tissue removed from a tooth 6 months after transplantation.

Fig. 4.—Pulp tissue removed 3 years after transplantation.

CLINICAL FINDINGS

The study has shown that the pulp, at least initially, seems not to have any influence on healing of the tooth. The healing conditions in our operational field are usually very good and with the right indications and correctly performed autotransplantation technique, the first phase in the healing is invariably favourable. The healing is, however, not completed until the regenerating alveolar bone has been completely adapted to the periodontal membrane of the tooth. This final phase of healing is dependent

on the amount of bone that has been sacrificed in the extraction, and we have found that the time required can range from 6 months to 2 years. It is only now that we have discovered that the continuous cementoid tissue can retain its natural protective effect in preventing resorption of the root from the alveolar bone.

Disturbance of this continuity in the cementoid tissue may be due to damage during the transplantation or malformation of the root, possibly with side canals from the pulp. Then we find in most cases incipient resorption of the root from

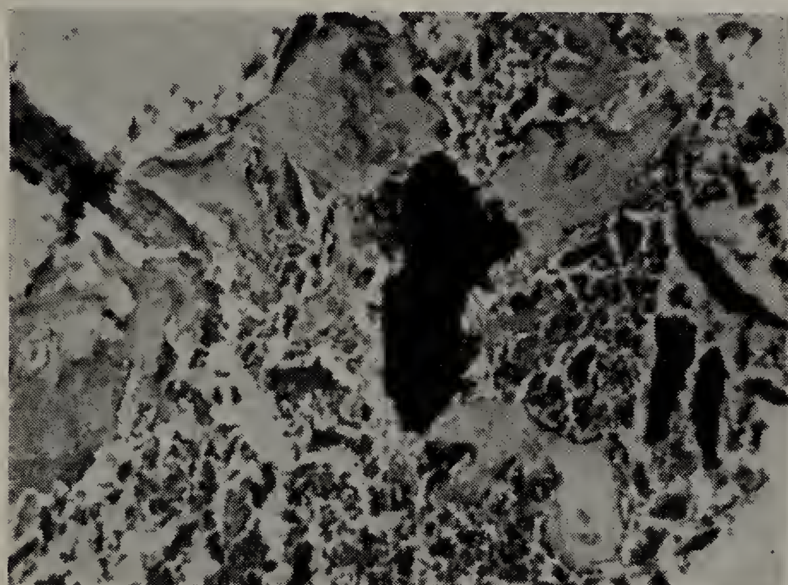


Fig. 5.—Pulp tissue removed 3½ years after transplantation. There are areas of calcification and degeneration.

Fig. 7.—Radiographs of canines. *Top right*, 12 months after transplantation. *Top left*, After root filling. *Bottom*, 4 years after transplantation.

the alveolar bone. First, there is resorption of the cementum and when the process reaches the dentine a communication to the pulp may result, and this in turn would seem to induce the formation of both internal and external granulation tissue. This tissue appears to increase the tendency for resorption. We have found that if this communication is interrupted at a fairly early stage, by removing the pulp and placing a root-filling, the resorption would seem to cease and under favourable conditions there is bridging of

Fig. 6.—Radiograph taken 5 years following root filling of tooth and curettage of resorption area.

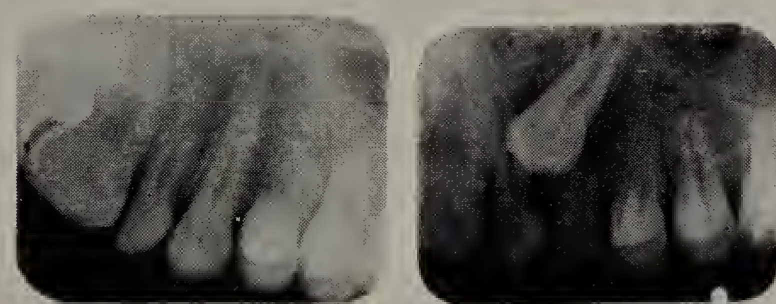


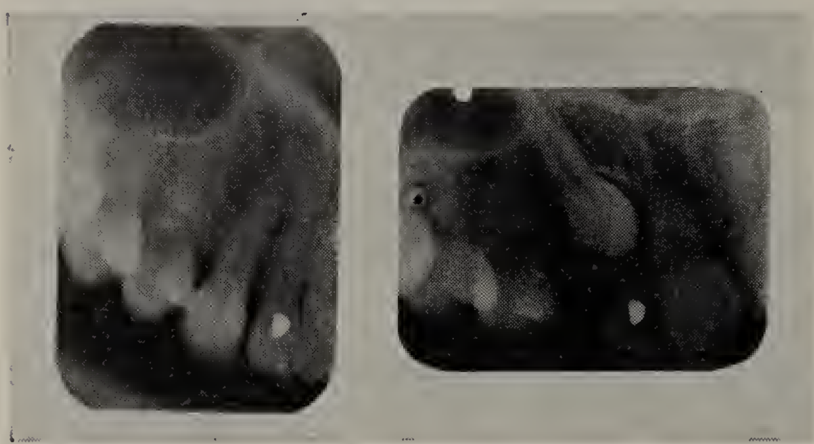
Fig. 8.—Radiographs of canines. *Right*, Prior to operation. *Left*, 4 years after operation.

the resorption site by new hard tissue. I would like to show two typical cases.

In the first case incipient resorption was observed after 6 months. After a further 2 months the pulp was removed and the tooth root filled. The result after 5 years is shown radiographically in *Fig.* 6. The tentative prognosis seems to be good.

In the next case a transplantation was performed in 1966. Healing was uneventful at first but the follow-up had to be interrupted because the patient was admitted to hospital for a lengthy period. When, 12 months later, the follow-up was resumed there was a fistula about half-way down the root. The radiographs showed extensive resorptions at this site. We then removed the pulp and filled the canal; at the same time the existing granulation tissue at the resorption site

was removed through an incision. Healing followed without complications and recent check showed that the resorption had clearly been arrested, and that there were signs of the formation of new hard tissue. In the review of the results we have counted this case as doubtful (*Fig.* 7).



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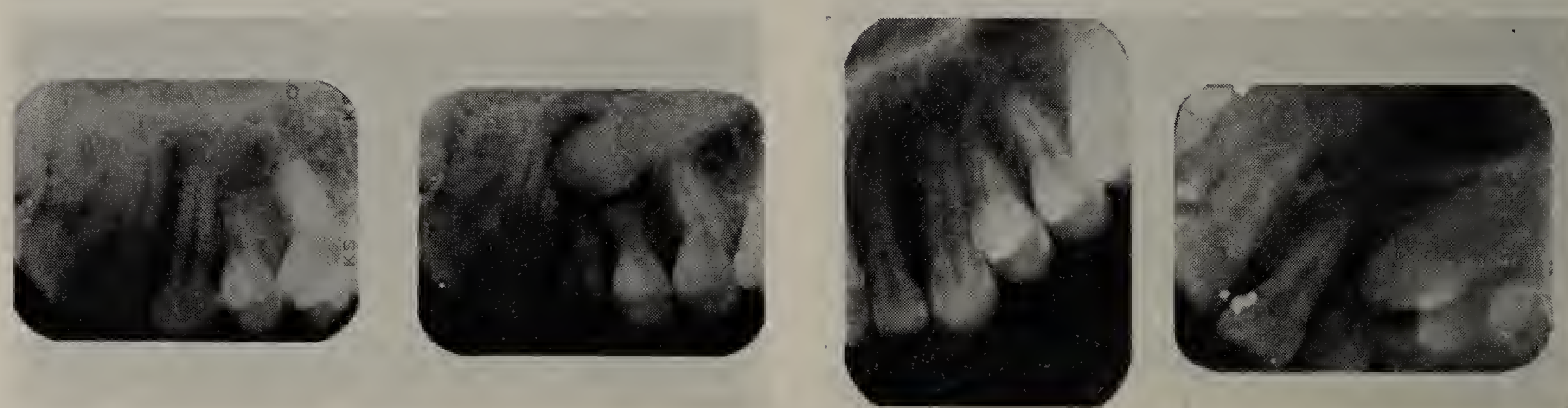


B C

Fig. 9.—Preoperative and postoperative radiographs of canines. A, 4 years after operation. B, 4½ years after operation. C, 3½ years after operation.

Table I.—Treatment of the Patients in the Original Series

- 51 Patients
  - 30 Root filling
    - 10 For the study
    - 5 Due to symptoms
    - 15 Root resorption
      - 10 Healing
      - 4 Dubious
      - 1 Extraction
  - 21 No root filling
    - 9 Pulpal calcification
    - 11 Healing uneventful
    - 1 Resorption

The study thus indicates the necessity for regular follow-ups for at least 2 years after the transplantation. If in the course of this period there is any evidence of root resorption, pulp extirpation and root filling should be performed without delay. I would mention that, as an outcome of discussions with our colleagues, the endodontists, we have during the last few years been performing the root filling in two stages. After removing the pulp the canal has been filled with calcium hydroxide paste, and 2 months have been allowed to elapse before placing the definitive root filling. The paste would seem to arrest resorption and promote healing. The root-filling material is made up of calcium hydroxide (15 g.) and Ringer's solution mixed to a paste.

ANALYSIS OF THE 5-YEAR REVIEW

When, 3 years ago, I gave an account of the preliminary study of the method, I pointed out that the follow-up time was too short to permit of definitive conclusions. Since we have now gained more than 5 years' experience of the method it might be rewarding to make a general appraisal of the cases that we have managed to follow up continuously for at least 3 years, and where we have been able to regard the healing of the tooth as concluded. The original series comprises 51 cases (*Table I*). A root filling was placed in 30 of these canines—in 10 of them as a step in the study to examine the reaction of the pulp histologically. In most of these 10 cases it proved that a root filling was not necessary. In the group of 5 where the teeth had been root filled due to symptoms, 3 patients had complained that the tooth was sensitive to cold, and in the other 2 cases a root filling was placed for safety's sake

when the patient for some reason had refused further examination. In 10 of the 15 cases in which there was resorption this process was arrested after the root filling and healing was satisfactory. In 4 of the cases healing was regarded as doubtful, and in another the transplanted tooth was extracted.

Of particular interest is the group of patients where no root filling was placed and where complete healing was recorded. These transplanted teeth showed a more or less marked positive response to the vitality test. In 9 of them, however, the vitality diminished at the same time as radiographs showed obliteration of the pulp chamber. In these cases it would seem that the conditions resemble those referred to in the literature as ‘ dystrophic calcification of pulpal tissue ’. The cause is said to be circulatory disturbance which can sometimes be observed in ordinary orthodontic treatment and also in traumatic occlusion. However, this calcification of pulp apparently has no functional or aesthetic implications. I refer to the studies of, for instance, Ramfjord and Ash (1966).

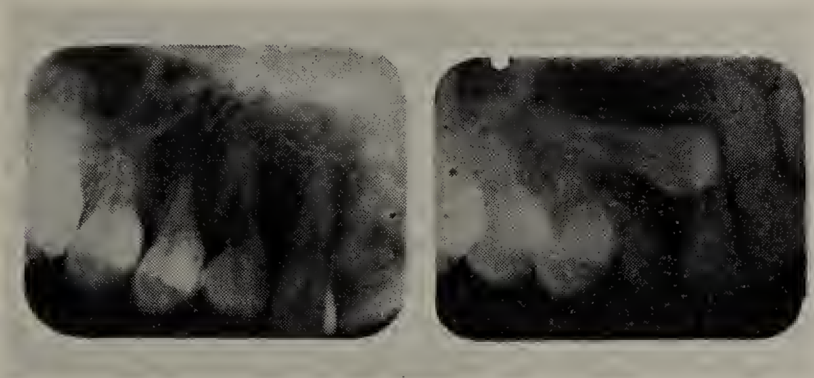


Fig. 10.—Radiographs of canines. *Right*, Prior to operation. *Left*, Extensive resorption seen 1 year after operation.

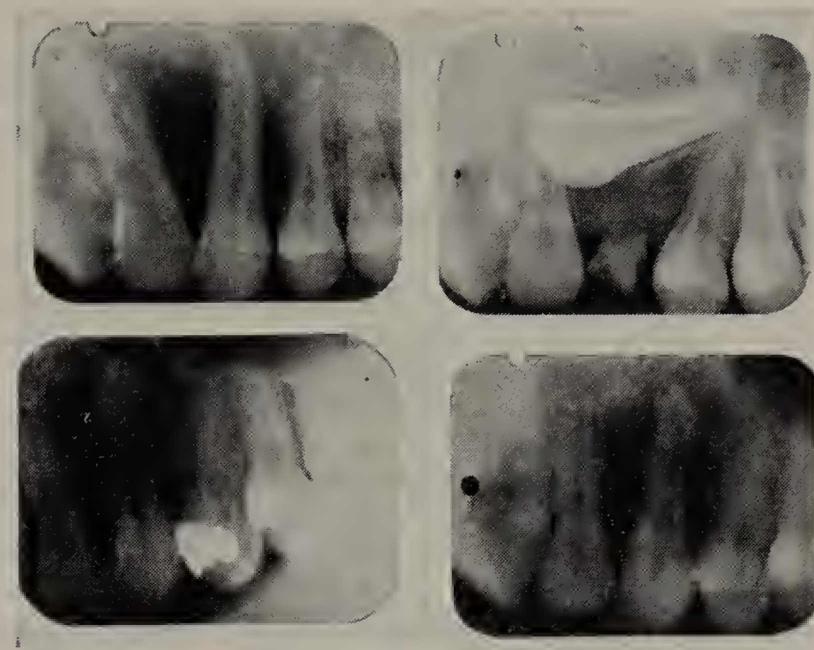
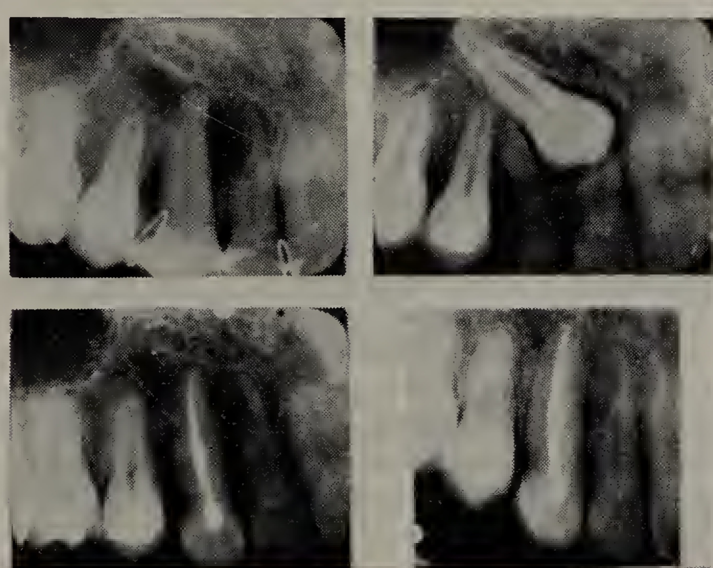


Fig. 11.—Radiographs of canines. *Top right*, Prior to operation. *Top left*, 12 months after operation. *Bottom right*, 3 years after operation. *Bottom left*, 4 years after operation.



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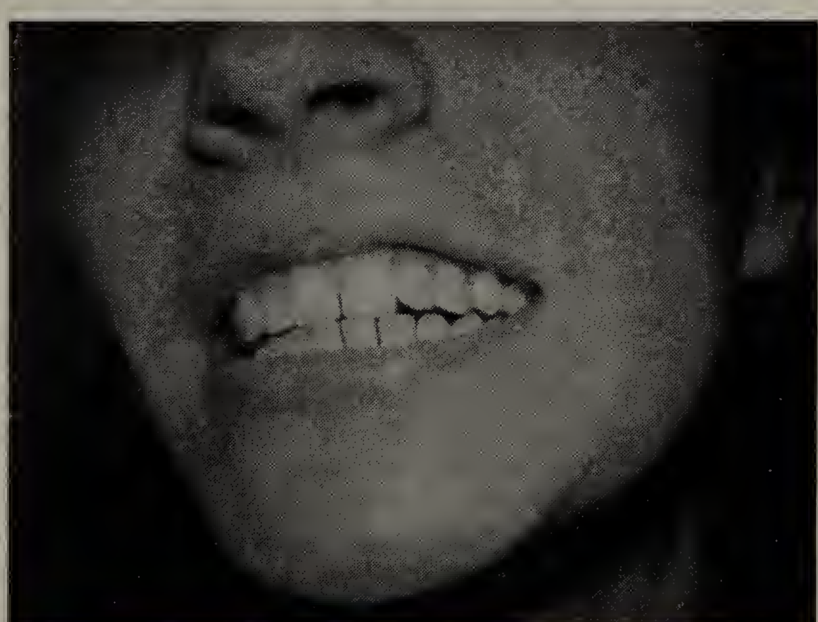

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Fig. 12.—A, Radiographs of canine prior to transplantation and at intervals up to 5 years. B and C, Photographs of same patient 5 years after transplantation of the upper left canine.

Radiographs of a representative case are shown in *Fig.* 8. The patient was a 14-year-old girl in whom a transplantation was performed at the end of 1965. The radiographs show an impacted canine. The canine was transplanted and healing was uneventful. Tests after 18

months showed an increase in vitality. After 3 years there was a reduction and at the same time radiographs showed a narrowing of the pulp chamber. After 4 years there was almost complete obliteration of the pulp.

In 11 cases the teeth are functioning normally. The radiographs in *Fig.* 9 demonstrate 3 typical cases. The first patient was a 16-year-old girl who was followed up for 4 years. The canine after this period is functioning normally. The second case is a girl of 14 years with a follow-up of 4½ years, and the third case, a girl of 16 years with a follow-up of 3½ years.

Table II.—Summary of Results

Result of Treatment	*No. of Patients*
Good healing without root filling	20
Good healing with root filling	15
Root resorption with good healing after root filling	10
Root resorption with dubious healing after root filling	4
Extensive root resorption	2

The series included 2 unsuccessful cases, and some details of these might be of interest. In one of them, a 13-year-old girl, the healing just after the transplantation seemed to have followed a normal course, but after 1 year fairly extensive resorption was observed (*Fig.* 10). An attempt at a root filling was unsuccessful and the tooth had to be extracted.

In the second case, a 16-year-old boy (*Fig.* 11), the transplantation was performed in April, 1966. Owing to the awkward position and the shape of the tooth the operation presented great difficulty and it was necessary to sacrifice much bone on the palatal aspect. Because of the large root it was also difficult to accommodate it in the alveolar process. For 18 months the healing seemed to follow a normal course, but then evidence of resorption was observed and this gradually increased. It is true that the tooth is still in place but it is only a matter of time before it falls out. With the experience that we have since accumulated of the method we could perhaps have dealt with these two teeth more successfully by removing the pulp at an early stage. The results are summarized in *Table II.*

CONCLUSION

To conclude, I would like to show the first case operated on by this method (*Fig.* 12). The autogenous transplantation was performed in October, 1964. The pulp was removed after 2 months for histological examination. Even though a root filling had to be placed, I think the therapy was good. We have saved the lateral, and the prognosis for the canine seems to be good. The young woman, who is now 22 years old, has recently given birth to a girl and it is my hope that this child will not have the same trouble with an impacted canine as her mother had.

I hope I have demonstrated that a continuous layer of cementoid tissue is of critical importance not only for the healing but also for the survival of the transplanted tooth. It follows then, that the success of an autogenous transplantation is dependent on the technical performance of the operation.

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DISCUSSION

Mr. B. B. J. Lovius, in opening the discussion, said that, together with many others who had heard Dr. Thonner when he came to England in 1967, he had started to follow the speaker's technique and had been getting some extremely good results. Some interesting points had arisen in the follow-up of patients.

Dr. Thonner had talked about the vitality of the teeth. Mr. Lovius said that he had removed the pulps and root filled a number of these teeth to date and in none of these cases had it been necessary to use any anaesthetic. One patient appeared to have some signs of calcification in the pulp canal. This was the only one in which some bleeding had occurred, and there appeared to be vital tissue within the pulp cavity. Was it possible that those teeth which had seemed so well radiographically, without any radiographic change, were still completely non-vital and a possible hazard to the future? (In reply to an enquiry by the speaker, Mr. Lovius confirmed that he had followed Dr. Thonner's method and used the patient's serum for temporarily storing the tooth whilst the new socket was being prepared.)

Dr. Thonner said in at least 50 per cent of the cases shown, the teeth were vital. He had extracted five pulps and found that all of them had well-stained cells and the pulps were vital, but, as shown in the paper, some cases had calcification in the pulp which was a very good sign. This meant that there was a reaction in the pulp. If this reaction was good there would be obliteration of the pulp. He hoped that the woman of 22 would have the tooth all her life. It looked very fine. If it looked a little darker with time something could be done about that. The root was perfect. This was the main thing. A tooth that was transplanted with the right technique always took; there was no doubt about that.

Mr. D. A. Dixon congratulated the speaker on his beautifully refined techniques. The method of producing a snare to withdraw the teeth was most important. It was absolutely fatal to grasp the tooth with a pair of forceps if one wished to implant. If one took out the tooth with forceps and replaced it the chances of success were much less than if the child had it kicked out and then replaced. Would Dr.

Thonner agree that this was partly due to the fact that many stress fractures were caused in a tooth grasped with forceps? It was almost like grasping a piece of toughened glass: it crazed and there were many areas opened for resorption. The speaker's beautiful snare technique was most valuable. Possibly here might be an explanation of the few cases of sensitivity to cold in that the snare was causing a little area of damage in the cementum part of the amelocemental junction. He had tried using a little device for grasping the enamel only of the tooth and drawing it out through traction. What did Dr. Thonner think of this?

The speaker's method of using natural serum was a marvellous one, and the term ' normal saline ' should be eliminated. It was a most abnormal material in which to put the tooth.

Dr. Thonner, in reply, said he thought Mr. Dixon was right.

Mr. C. D. Parker, referring to the periodontal membrane, asked whether Dr. Thonner thought that the interruption of innervation had any permanent effects. He was thinking in terms of the traumatic relationship which may develop. Dr. Thonner had said that some of the changes seen were similar to the effects of trauma.

Dr. Thonner said that it must happen sometimes. It was not a real, normal, pulp tissue but it would fulfil the same purpose as a pulp. The narrowing of the pulp was a very good sign of success with the transplantation. It was always a matter of concern when after 3 or 4 years the pulp was as large as before. In such cases the answer was to take out the pulp. A test was always done to find out whether the pulp was sterile. It was very easy to take out the pulp in one piece. Perhaps Mr. Parker observed this.

Mr. D. G. Huggins said that he had been encouraged by Dr. Thonner's paper in 1967 to follow his technique. He had introduced a small variation which might be of interest to Dr. Thonner. When one reached the stage of snaring the teeth it was most important not to impinge on the cementum, and one attempted to encircle the enamel only. The snare was used to suspend the tooth in the serum at that stage rather than dropping the tooth into it as had been previously suggested. He felt that this was more logical in avoiding any damage to the root surface. This technique had been very successfully employed. Subsequent to transplanting one of these canines he had had occasion to move the tooth using orthodontic appliances. This had proved to be very successful. What were Dr. Thonner's comments on this procedure?

Dr. Thonner said that when the tooth had healed it was just the same as a tooth that had not been transplanted.

Mr. T. W. Weinberg asked whether Dr. Thonner found that the results of an operation varied, depending on the state of closure of the apex of the tooth at the time of operation, bearing in mind the results of studies on traumatically avulsed teeth which had shown that the prognosis was much better if the apex were widely open.

Dr. Thonner said that they always waited as long as possible to make a transplantation. It did not matter whether there was an open or a closed apex. The best time to make a transplantation was at 15 or 16 years. The only trouble was that one had to wait and take it easy for about 15 years! It was very important to take an X-ray before taking out a deciduous canine. Many people thought that the deciduous canine had rested for 15 years and that if it were taken out the real canine would erupt, but if the canine were displaced by more than 45° horizontally it would never erupt even if the deciduous canine were taken out. If the deciduous canine were taken out too early the result was the resorption of the alveolar process on the buccal aspect, and then a transplantation could not be done. There must always be sufficient bone around the root if a transplantation were to be done successfully.

The President suggested that any further points should be discussed privately with Dr. Thonner afterwards, in view of the shortage of time. He wondered how many of those present, if asked to do so, could deliver a speech to a scientific body in Stockholm in perfect Swedish! Dr. Thonner, who was not only a regional consultant in orthodontics but also in oral surgery, had brought a great deal of experience as well as skill to his subject, and they were all greatly indebted to him for giving the twenty-fourth Northcroft Memorial Lecture.

The vote of thanks having been carried by acclamation, the *President* then presented Dr. Thonner with the script to which every Northcroft lecturer was entitled.

A PRELIMINARY SURVEY INTO THE ASSOCIATION OF THE FRANKFURT-MANDIBULAR-PLANE ANGLE WITH INTERDENTAL 'S' AND INCISOR RELATIONSHIP

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INTRODUCTION

In the course of clinical examination of patients it was felt that there might be some significant relationship between Frankfurt-mandibular-planes angle (F.M.P.A.) and the production of an interdental ' S '. An attempt was made to investigate this relationship and correlate it with other factors such as overjet and overbite.

Speech is a function superimposed upon structures used for other activities and is learned over a period of several years. Most children at the age of 7–8 years have learnt the basic motor skills needed to produce speech which is acoustically satisfactory and is accepted as normal (van Riper, 1963).

Of all speech sounds the linguo-alveolar fricative ' S ' is produced with the highest frequency. This sound is the one most likely to be defective. One might ask what constitutes defective speech and van Riper and Irwin (1959) answer this by saying: ' Speech is defective when it deviates so far from the speech of other people that it calls attention to itself, interferes with communication, or causes its possessor to be maladjusted.'

During the production of the sounds ' S ' and ' Z ' (' Z ' being voiced) the tip of the tongue is placed behind the upper and lower incisor teeth with the edges of the tongue contacting the lingual surfaces of the posterior teeth and the gingival area of the palate, air being expelled through a narrow anterior channel (Hopkin and McEwen, 1955).

Although the production of the ' S ' sound has been investigated no successful attempt has yet been made to find a correlation between skeletal and dental abnormalities and the production of the ' S ' sound. Van Thal (1935) examined 180 orthodontic patients and found that 90 per cent had errors or defects of speech. However, she considered that although a malocclusion has an unfavourable influence on speech, it was not justifiable to regard it as the actual cause of articulatory defects such as lisping. Hopkin and McEwen (1957) examined 101 school children between the ages of 5 and 15 years attending speech therapy clinics in Edinburgh. Their results showed that, in general, speech defects were as likely to be found in normal occlusions as in malocclusions.

INTENTION

In the present study it was decided to investigate a possible relationship between F.M.P.A., overjet, overbite, and interdental ' S '. In view of the lack of numbers investigated in previous surveys, and the fact that the incidence of interdental ' S ' in the population available for personal study is so small that the numbers would be insufficient to establish such correlations with any degree of accuracy, the material available from the Wessex Survey was used.

METHOD

Records on a standardized analysis sheet were kept by the orthodontic consultants from the Wessex region covering the areas of Portsmouth, Bournemouth, Southampton, and Winchester. The same orthodontic analysis sheet was used by all the operators and individual assessments of the patients were made. The records were submitted to a data processing machine which was used to analyse the results obtained under the headings F.M.P.A., Overjet, Overbite, and Interdental ' S '.

Presented at the Country Meeting held on 14 May, 1970.

The records of 1436 cases were examined. The F.M.P.A. was listed as being high, normal, or low. A normal angle was taken to be between 22° and 30°. This was actually measured by one operator by means of a protractor and assessed subjectively by the other operators.

The overjet was classified as increased, normal, decreased, edge-to-edge, and reversed. A normal overjet was taken to be between 2 and 3 mm. Anything more than this was considered to be increased and anything less was taken to be decreased.

The overbite was classified as being increased, normal, reduced, incomplete, and open bite. Where the upper incisors overlapped the crowns of the lower incisors vertically by more than 3–4 mm., it was taken to be increased. The overbite was considered to be incomplete when the incisal edges of the lower incisors failed to make contact with the palatal surfaces of the maxillary incisors or the palatal mucosa. The Angle's classification for each case was also noted.

Speech was noted as being either normal or interdental ' S '. An interdental ' S ' was defined as a speech defect confined to the faulty production of the ' S ' sound. This was ascertained by asking the patients to pronounce a word or phrase containing several ' S ' sounds which were assessed subjectively by the orthodontist.

Table I.—The Relationship between Angle's Class and Interdental ' S ' and the Percentage of these Cases with a High F.M.P.A.

Angle's Class	Percentage with Interdental ' S '	Of the Cases with Interdental ' S ' Percentage with High F.M.P.A.
Cl. I	3·2	10·3
Cl. II, div. 1	10·2	28·2
Cl. II, div. 2	2·5	0
Cl. III	6·3	10·7

As not all cases had their age recorded, it was not possible to analyse in detail the incidence of interdental 'S' with age. Instead, the cases in which the age had been recorded were divided into two groups, those before and those after the eighth birthday.

FINDINGS

1. The records of 1436 cases were examined. The results as shown in *Table I* where the full 1436 cases were examined were particularly interesting. Of 394 Angle's Class II, div. 1 cases 41 or 10·2 per cent had an interdental ' S ' and of these 41 cases, 13 or 28·2 per cent had a high F.M.P.A. Only one Class II, div. 1 case had an interdental ' S ' in combination with a low F.M.P.A. It would appear, therefore, that the interdental ' S ' occurs with the greatest frequency in the Class II, div. 1 case and often together with a high F.M.P.A.

2. *Table II* shows the relationship between F.M.P.A. and interdental ' S '. It can be seen that 14·7 per cent of the cases with a high F.M.P.A. had an interdental ' S ' and of these 14·7 per cent cases 25·9 per cent had a reduced overbite as well. It thus appears that the incidence of interdental ' S ' is increased in cases with a high F.M.P.A.

Table II.—The Relationship between F.M.P.A. and Interdental ' S ' and the Percentage with Reduced Overbites

F.M.P.A.	Percentage with Interdental ' S '	Of the Cases with Interdental ' S ' Percentage with Reduced Overbite
High	14·7	25·9
Normal	3·9	7·2
Low	4	0

3. There were 185 cases with ages recorded in the 1–8 year group. Out of these, 13 cases (7·5 per cent) had an interdental ' S '. Out of 1000 cases above 8 years of age, 41 cases (4·1 per cent) had an interdental ' S '. Although the two groups are of unequal size there are sufficient cases to suggest that age may be an important factor, as the incidence of interdental ' S ' is shown to be decreased with age. This supports the view that until about 8 years of age a child's speech may still be in the developmental stage, depending on several factors such as physiological and psychological development and maturity.

SIGNIFICANCE

The figures obtained under interdental ' S ' were assessed against the results obtained for F.M.P.A. and Angle's classification for statistical significance. The value of chi^2 was calculated and using the ' null hypothesis ' it was found that the probability of the results being due to chance was less than 5 per cent ($P<0·01$). The statistical significance between high F.M.P.A. and reduced overbite was also investigated. A value of $P<0·001$ would suggest that there was some association between the two.

Since the records of more than one operator have been used in this survey, a factor of observer variability has been introduced. To check if there was evidence of observer variability, the records from individual operators were taken and the observed and the expected values for normal and interdental ' S ' were calculated. As can be seen in *Table III* there is very little difference between

observed and expected values and the value of chi^2 was calculated to be 0·37326, suggesting absence of observer variability with regard to the incidence of interdental ' S '.

SUMMARY

The records of 1436 cases were investigated for the association between F.M.P.A., interdental ' S ', and incisor relationship.

Table III.—RESULTS SHOWING ABSENCE OF OBSERVER VARIABILITY

OBSERVER	NORMAL ' S '	INTERDENTAL ' S '
A	374 (371·650)	19 (21·350)
B	512 (512·501)	30 (29·449)
C	472 (473·754)	29 (27·243)

The figures above are observed numbers and the figures in brackets show expected values.
χ^2=0·37326.

The results showed that there was a significantly higher percentage of cases with an interdental ' S ' in an Angle's Class II, div. 1 malocclusion and these cases also had a higher percentage with a high F.M.P.A. The assessment of interdental ' S ' was subjective but had the advantage that it would include those abnormalities most likely to be noticeable to the general public and which, of course, are the important ones. This is supported by the absence of observer variability as shown in *Table III.* The incidence of interdental ' S ' has also been shown to be increased in cases with a reduced overbite.

It is well known that soft-tissue morphology and behaviour can adapt to some extent to an adverse skeletal pattern, attempting to produce normal function. The same would seem to be true in the case of speech. However, when the abnormality becomes extreme a proportion of individuals produce a defective ' S '. Presumably such individuals are less able to adapt, although of course, skeletal factors are not the only cause of such an abnormality.

As the title of this paper indicates this is a preliminary survey being based on clinical statistics prepared in the normal course of examination of patients for treatment purposes. A further survey is called for using cephalometric measurements of skeletal pattern and F.M.P.A. and with more precise definition of interdental ' S '. It would appear, for instance, that some individuals can make a normal sounding ' S ' with an interdental tongue position. Larger numbers would also make it possible to break down the incidence of interdental ' S ' in each age-group. It is felt, however, that these statistics are sufficient to indicate correlations worthy of further investigation.

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A LONGITUDINAL STUDY OF THE SN-MANDIBULAR-, FRANKFURT-MANDIBULAR-, AND MAXILLARY-MANDIBULAR-PLANE ANGLES

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INTRODUCTION

The determination of skeletal pattern is an important part of orthodontic diagnosis, and in order to analyse and understand a malocclusion not only is it necessary to relate maxillary teeth to mandibular teeth, but also the basal bones on which these teeth are placed. The descriptive criteria generally employed for the maxillary-mandibular relationship are the angle SNA–SNB difference in the horizontal or anteroposterior plane, and the Frankfurt-mandibular or maxillary-mandibular-plane angles in the vertical plane. It is the latter, describing the vertical relationship between the maxilla and the mandible, especially the change in this relationship with age, which forms the subject of the present study.

A number of longitudinal growth studies have been carried out in various parts of the world to investigate the changes in the skeletal pattern with age, but none have specifically dealt with the vertical relationship as described by the Frankfurt-mandibular- and maxillary-mandibular-plane angles in the early age-group, although the relevant planes have been referred to indirectly by several workers. Broadbent (1937) and Brodie (1941) were the first workers to use cephalometric techniques to investigate systematically the growth pattern of the jaws and from their work they came to the conclusion that the morphogenetic pattern of the human skull is established at a very early age and once attained it does not change. They observed that the facial planes moved in a parallel fashion and the various landmarks followed a straight line progression. Their findings, however, were based on composite tracings, and therefore overlooked the individual differences. In his later work Brodie (1953) recognized individual variability and noted that in those cases which exhibited some change, the nasal floor increased its angular relation with the anterior cranial base, while the orientations of the mandibular and occlusal planes became more parallel.

Björk (1950) and Lande (1952) while supporting the constancy concept of skeletal pattern in principle, did not agree that the facial proportions were rigidly fixed. Björk (1950) from his cross-sectional study of the 12–21 age-group, showed that the facial axis did alter its relationship to the cranial base, and that the mandible became more prognathic with age. Lande (1952) confirmed the increase in mandibular prognathism and further observed that this increase was associated with decrease in the angle of convexity and in the angulation of the lower border.

Frankel (1966) studying more specifically the changes in the mandibular plane between 10 and 12 years noted that this plane descended in a non-parallel fashion, the gonion descending at a faster rate than the gnathion. In a more complete study of 60 subjects from 3 years to 16 years Bergerson (1966) found that at the older ages growth at the menton is related to the steepness of the mandibular plane—a steep plane shows more vertical and less horizontal growth than a flat or horizontal plane.

In a recent systematic analysis of maxillary-mandibular-plane angles Atherton (1964) found that there was a significant decrease in this angle between the ages of 10 and 20 years (the mean decrease was of the order of 2·25°).

The present investigation is similar to that of Atherton except that the children studied belong to an earlier age-group.

MATERIAL AND METHODS

The children constituting the sample were of British origin, all born in King's College Hospital with a high proportion of first-born. The sample was as near random as possible, and could be called self-selected in the sense that the

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children were allowed to drop out if they so wished.

The material investigated consisted of cephalometric radiographs of 74 children taken at yearly intervals from 4 to 14 years. Only the first and the last radiographs of each patient with an average age difference of 10 years were traced and compared.

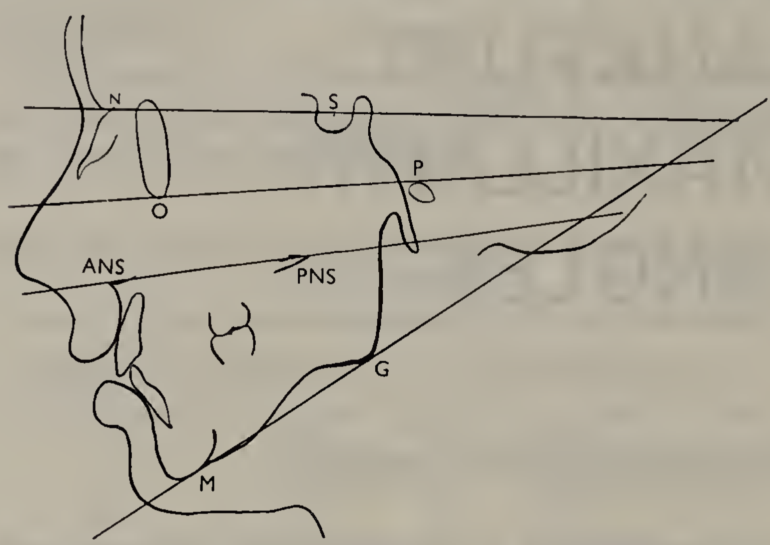

Fig. 1.—A tracing of a cephalometric radiograph showing the relevant landmarks used in the study. N, Nasion. S, Sella. O, Orbitale. P, Porion. ANS, Anterior nasal spine. PNS, Posterior nasal spine. M, Menton. G, Gonion.

The relevant landmarks describing the SN, Frankfurt, maxillary, and mandibular planes are defined as follows (*Fig.* 1):—

Nasion

The anterior end of the nasofrontal suture.

Sella

The centre of the sella turcica.

Orbitale

The lowest point of the infra-orbital margin. In the case of double shadows the intermediate position between the two points was taken as representing the landmark.

Porion

The highest point of the external auditory meatus.

Anterior Nasal Spine

The most anterior point on the shadow of the anterior nasal spine.

Posterior Nasal Spine

The most posterior point on the shadow of the posterior nasal spine.

Menton

The lowest point of intersection of the lower border of the mandible and the shadow of the symphysis.

Gonion

The point where the line bisecting the angle formed by tangents to the lower and posterior borders meet the border of the ramus.

SN Plane

The line joining the sella and nasion.

Frankfurt Plane

The line joining the orbitale and porion.

Maxillary Plane

The line passing through ANS and PNS.

Mandibular Plane

The line joining the menton and gonion.

Table I.—Statistical Summary of the Measurements of Maxillary-mandibular-, Frankfurt-mandibular-, and SN-Mandibular-Plane Angles taken from Radiographs of Seventy-four Children at 4 and 14 Years

Angle Measured	Age (years)	Mean	Range	Standard Deviation
Maxillary-mandibular-plane angle	4	30·16°	21·5°–41·0°	±4·4
Maxillary-mandibular-plane angle	14	27·01°	14·5°–39·5°	±5·8
Frankfurt-mandibular-plane angle	4	28·73°	18·0°–39·0°	±4·5
Frankfurt-mandibular-plane angle	14	26·40°	15·0°–40·0°	±5·5
SN-mandibular-plane angle	4	36·77°	26·0°–47·5°	±4·6
SN-mandibular-plane angle	14	34·88°	22·0°–47·0°	±6·2

Table II.—The Changes in the Three Angles from 4 Years to 14 Years

Angle Measured	Mean Change	Range Deviation	Standard Deviation	Statistical Significance
Maxillary-mandibular-plane angle	−3·15°	−10·5° to +4°	±3·9	0·001
Frankfurt-mandibular-plane angle	−2·33°	−13° to +5°	±4·1	0·001
SN-mandibular-plane angle	−1·9°	−12·5° to +6°	±4·4	0·001

The angles measured were (1) the SN-mandibular plane angle, (2) the Frankfurt-mandibular-plane angle, and (3) the maxillary-mandibular-plane angle.

All radiographs were traced on two separate occasions and in the case of a difference the mean of the two was taken as the final reading.

Table III.—MEAN CHANGE IN MAXILLARY, FRANKFURT AND MANDIBULAR PLANES FROM 4 YEARS TO 14 YEARS. THE TRACINGS WERE SUPERIMPOSED ON THE SN PLANE WITH REGISTRATION ON THE SELLA

PLANE	MEAN CHANGE	RANGE	STATISTICAL SIGNIFICANCE
Maxillary	+1·25°	−4° to +8°	0·01
Frankfurt	+0·43°	−6° to +8°	0·01
Mandibular	−1·9°	−12·5° to +6°	0·01

RESULTS

The measurements of the three angles obtained from the tracings of the cephalometric radiographs of the children at the ages of 4 years and 14 years were analysed statistically. A summary of this analysis is presented in the *Tables I*, *II*, and *III*.

DISCUSSION

It is apparent from the results that a composite picture of growth is different from that of the individual patients. The mean changes from 4 to 14 years in the SN-, Frankfurt-, and maxillary-mandibular-plane angles are of the order of −1·9°, −2·33°, and −3·15° respectively, suggesting only small changes in the skeletal pattern in the vertical plane. However, a look at the individual cases reveals considerable variation in the skeletal relationship. There were 34 cases where the maxillary-mandibular-plane angle, for example, altered by 4° or more, in 12 cases by 8° or more, and in 2 cases the decrease was as much as 10°. The SN- and Frankfurt-mandibular-plane angles show a similar behaviour. This is in accordance with what Björk (1950) and others have said on the growth of the jaws. Individual variations are a persistent phenomenon in the longitudinal growth studies and the constancy of the skeletal pattern should only be discussed in terms of composites.

Generally speaking, there is a tendency in these angles to decrease with age; the decrease is most marked in the maxillary-mandibular-plane angle, and the least in the SN-mandibular-plane angle with the Frankfurt-mandibular-plane angle occupying intermediate place (*Fig.* 2). The relative contributions of the SN, Frankfurt, and maxillary planes to this decrease were measured by superimposing the tracing on the SN plane and registering on the sella. The mandibular plane seems to make the maximum contribution (mean change, −1·9°), the maxillary plane slightly less (mean change, +1·25°), and the Frankfurt plane the least contribution (mean change, +0·43°) to the decrease in the respective angles. On the whole, the mandibular plane tips down at the back, the growth at the gonion being greater than at the menton. The maxillary plane, however, moves in the opposite direction, tipping downwards in front as a result of the greater growth at the ANS than at the PNS. The total effect of this movement of the two planes in the opposite direction is that the decrease in the maxillary-mandibular-plane angle is much more than the other two angles. The downward descent of the Frankfurt plane is more or less parallel. *Table III* shows the range of changes in the three planes with relation to the SN plane. Again it is obvious that the individual variations far exceed any picture of the constancy of the skeletal pattern that may have been created by the means.

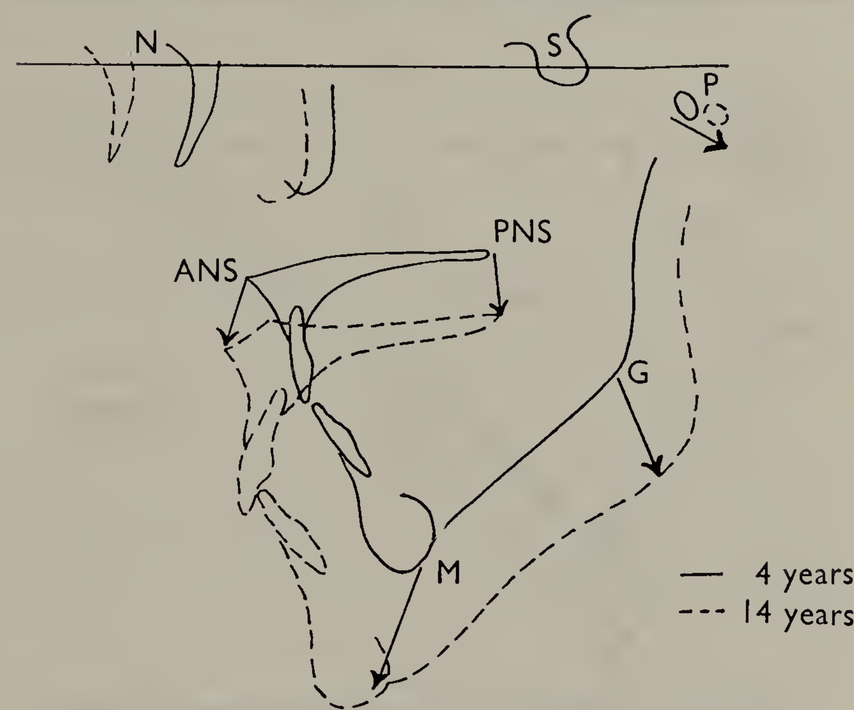

Fig. 2.—Tracings of cephalometric radiographs showing the general direction of growth of the relevant landmarks from 4 years to 14 years.

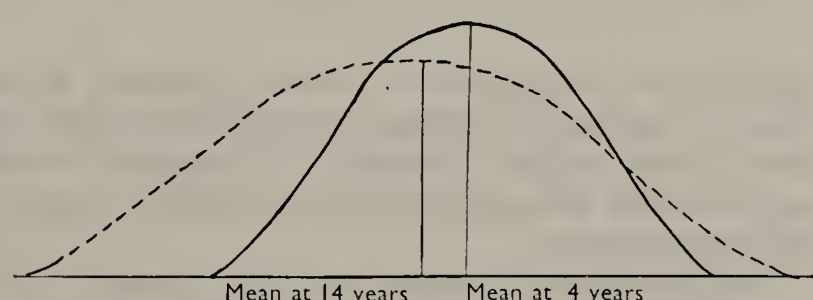

Fig. 3.—Graphic representation of the change in the distributions of the angles seen in the angles from 4 years to 14 years. A reduction in the mean is accompanied by an increase in the standard deviation indicating an increase in variability with age.

A high correlation is noted between the Frankfurt-mandibular- and maxillary-mandibular-plane angles which is of the order of $+0{\cdot}78$ at the age of 4 years and $+0{\cdot}77$ at the age of 14 years, and significant at 0·01 level at both ages. This suggests that it is legitimate to deduce the maxillary-mandibular-plane angle from the clinical assessment of the Frankfurt-mandibular-plane

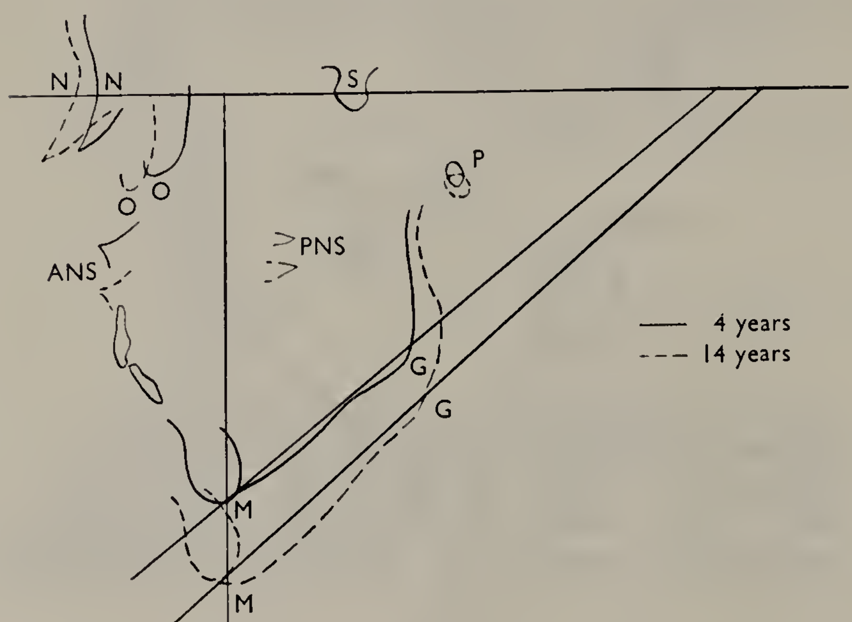

Fig. 4.—Tracings of the cephalometric radiographs of *Case* A showing only downward growth at the menton. The SN-mandibular-plane angle shows an increase of 1° at 14 years.

angle, as is often done in clinical practice. However, it should be borne in mind that there are some cases where increase or decrease in one angle is not associated with a similar change in the other angle.

An interesting feature of this change is the transformation of the distributions of these angles from 4 years to 14 years which is evident in all the three angles. This transformation is graphically represented in *Fig.* 3. A reduction in the means of the angles is accompanied by an increase in their standard deviations (the standard deviation has altered from $\pm 4{\cdot}4$ to $\pm 5{\cdot}8$ in case of the maxillary-mandibular-, from $\pm 4{\cdot}5$ to $\pm 5{\cdot}5$ in the case of the Frankfurt-mandibular-, and from $\pm 4{\cdot}6$ to $\pm 6{\cdot}2$ in case of the SN-mandibular-plane angles) (*Table I*) indicating an increase in the variability of the population. This could of course be interpreted as a natural course of events—growth and maturation bringing about fuller expression of the genetic pattern, perhaps allowing the environment a chance to interact, and thereby sharpening the individual differences and increasing the population variability. If this is so, then one should expect some changes in the skeletal pattern with age and some individuals breaking away from the set course.

Two cases in the study are worth mentioning. *Case* A (*Fig.* 4) where the SN-mandibular-plane angle has remained constant (change of only 1°) and *Case* B where the angle has decreased by as much as 10° (*Fig.* 5). In *Case* A there has been practically no horizontal growth at the menton; the only growth seen is in the downward direction. In *Case* B, where there has been considerable decrease in the angle, the growth at the menton has been predominantly horizontal. This pattern is seen to some degree in other cases too—the horizontal growth at the menton is associated with a decrease in the angle, whereas the vertical growth is accompanied by more or less parallel

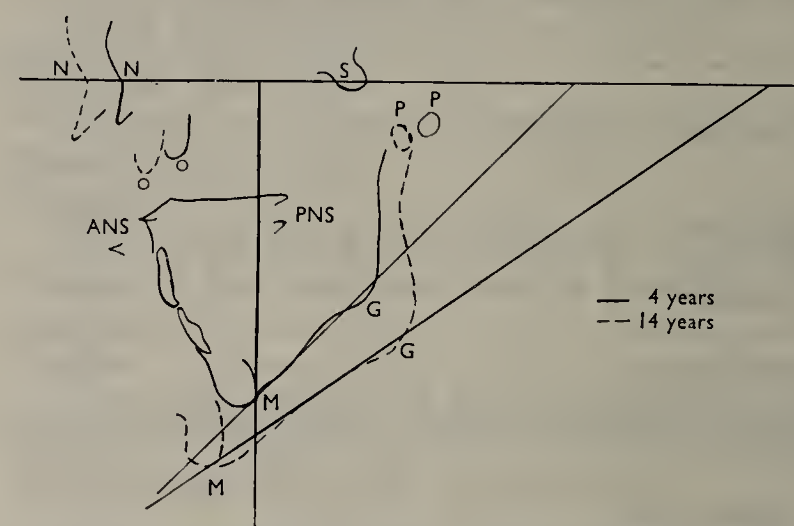

Fig. 5.—Tracings of the cephalometric radiographs of *Case* B showing predominantly horizontal growth at the menton. The SN-mandibular-plane angle shows a decrease of 10° at 14 years.

descent of the mandibular plane. This is in accord with Bergerson's (1966) earlier findings that a horizontal growth vector at the menton is associated with an unparallel descent of the mandibular plane and this descent becomes more parallel as the vertical growth vector increases.

CONCLUSION

A longitudinal study of the SN-mandibular-, Frankfurt-mandibular- and maxillary-mandibular-plane angles was carried out, based on the cephalometric records of 74 children of British origin with ages ranging from 4 to 14 years.

The mean changes found in these angles were $-1{\cdot}9°$, $-2{\cdot}3°$, and $-3{\cdot}1°$ respectively.

The changes in the angles are contributed to by changes in all three relevant planes.

Although the mean changes in the angles are not of a high order, the wide individual variations support the earlier findings that variation rather than constancy is the rule in the growth of the skeletal pattern.

Acknowledgements

This work is based entirely upon records from the King's College Hospital Dental School growth study. I should like to acknowledge the help given me by Professor B. C. Leighton and permission to use growth study records. I am indebted

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SPEECH AND INTELLIGENCE IN ADULT CLEFT-PALATE PATIENTS

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One of the intriguing problems in cleft-palate patients is the relationship of speech to intelligence. It is surprising how little work has been done on this.

Illingworth and Birch (1956), used the Terman and Merril I.Q. test on 80 cleft-palate children at Sheffield, where they found a mean I.Q. of 95·4 (S.D., 19·5) compared with an assumed I.Q. of 100 for the population. They compared their results with a study by Kennedy-Fraser (1949) of 1215 11-year-old Scottish children, who had a mean I.Q. on the same test of 102·5 (S.D., 20·05). Illingworth (1963) suggested that the mean I.Q. of cleft children was lower than that of the population as a whole. It is extremely difficult to make comparisons of this kind, not only because the two groups compared were from different parts of the country, but also because the Scottish educational system is very different from the English system.

Fogh-Anderson (1943) found 59 cases of cleft lip and palate among 17,000 feeble-minded individuals examined by the University Institute of Human Genetics, Copenhagen, when the expected incidence was only 20. Here again other factors such as concomitant abnormalities had not been investigated.

In the United States Goodstein (1968) suggested that the indications were that children with cleft lip and palate were significantly impaired, on average, in their intellectual development, and that the impairment was greatest in the area of verbal intellectual skills. Morris (1968) suggested that 4–6 per cent more cleft children than the total population of children had intelligence levels which could be considered as aetiological factors for slowness in learning speech. Some studies have been carried out using various I.Q. tests to assess the cleft patients, but they have not included any matched control groups, whilst others using control groups have tended to use them matched on the bases of age, sex, birth order, family size, socio-economic status, etc.

One of the most important factors in the development of vocabulary is the child's environment. Changes of this environment, especially where health is concerned, can result in a slowing-down of the growth of a child's developing vocabulary. It is usual for cleft patients to spend periods, every few years, in hospital, almost from birth onwards, for surgery to be undertaken to repair the lip, then the palate, then perhaps a palate lengthening or a pharyngoplasty. In addition there may be an ascending infection up the eustachian tube, necessitating visits to an ear, nose, and throat clinic and perhaps more hospitalization. There is also the regular care by the dental surgeon, speech therapy, orthodontic treatment, and perhaps even psychiatric aid. All this involves stays in hospital and many out-patient attendances, almost throughout the whole childhood period. It thus means that considerable periods of schooling are missed—schooling which certainly is not made up when cleft-palate children are in hospital, and this can add considerably to their difficulties.

It therefore seemed preferable to choose a control group of people who had similarly spent periods in hospital and had attended as out-patients many times, and those 'long-term' orthopaedic patients (poliomyelitis, congenital dislocations of the hips, and scolioses patients) who satisfied these criteria were selected. They were seen whilst attending out-patient clinics, in physiotherapy departments, as in-patients, and by visiting them at their homes. It was thus possible to find a control group matched with the cleft group for age and sex, and also for the long periods of hospitalization. This group also came from the same area (Liverpool) and thus had had similar schooling and regional background.

Altogether 40 cleft-palate and 21 control-group patients were seen. For the purpose of this study they were deemed adult if they were 14 years of age or older. The cleft group consisted of adults with a cleft palate, repaired or unrepaired, wearing a prosthesis or not. The cleft group were sent for by letter to attend at the Dental Hospital, Liverpool, for this investigation. It is realized that this has certain disadvantages in that it is probable that the majority of people who reported would have been capable of comprehending the

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letter and/or grateful for their treatment. The speech was recorded using a high quality tape-recorder, so that it could be re-assessed at a later date to confirm its category. The patients were classified into six groups, using categories that Green (1957) had used in an earlier study. (*Recordings of patients were then played to illustrate the different categories.*) *Table I* summarizes the categories used. No patients were found in category 6.

Table I.—Speech Categories of Cleft-palate Patients

Speech Category	No. of Patients	Description
1	10	Normal speech, having a normal voice and normal articulation
2	1	Normal speech, except for defective articulation of one consonant which was usually S or K
3	3	Normal voice, defective articulation of more than one consonant. The articulatory defect may vary, from 2 to 3 consonants being replaced by abnormal fricatives or glottal stops, or there may be simple substitution of one normal consonant for another normal one such as K for T or vice versa
4	14	Inconsistent nasal tone of voice with correct articulation of all the consonants. Audible nasality being detected off and on
5	12	Inconsistent nasal tone of voice with abnormal articulation of consonants. Audible nasality detectable and made more obvious by the articulatory defects
6	0	Typical cleft palate speech, with consistently nasal voice and all consonants except nasals replaced by typical cleft palate sounds, i.e., glossopharyngeal fricatives and glottal stops

In categories 1–4 inclusive, speech is intelligible, 5 may be difficult to understand at times, and 6 is often unintelligible.

Table II.—Numbers of Individuals with Significant Discrepancies between Progressive Matrices and Mill Hill Vocabulary Scores

Comparison of Indices	No. of Patients		
	Cleft	Controls	Totals
Progressive matrices > Mill Hill vocabulary score	16	7	23
Mill Hill vocabulary > Progressive matrices score	4	5	9
Totals	20	12	32

As category 2 is almost normal, and category 5 is more difficult to understand than 3 or 4, it was decided for the purpose of this study to regroup them with 1 and 2 together, 3 and 4 together, and 5 and 6 together, this giving 3 gradations of intelligibility of speech. The intellect was assessed using Raven's standard progressive matrices sets A, B, C, D, and E, and the Mill Hill vocabulary scale (Raven, 1958). The matrices give an indication of a person's intellectual capacity relative to other people of his own age and the frequency with which one should expect to find people of similar intellectual capacity. The vocabulary scale provides a reliable index of the best intellectual level a person has attained whatever his present capacity for intellectual activity may happen to be. The two tests are designed for use together in place of a single verbal test of general intelligence, so that it is possible to assess separately and in a clearly defined form (1) his present capacity for intellectual work, (2) the fund of verbal information he has acquired so far, and (3) the psychological significance of discrepancies between (1) and (2).

RESULTS

There was no significant difference between the cleft-palate and control groups' mean age of 22 years ($t=0{\cdot}1455, P>0{\cdot}8$). There was no significant

difference between the cleft and control groups on the Mill Hill vocabulary scale (t=0·6160, P>0·5) or on the progressive matrices (t=0·1020, P>0·9). An individual should score similar values on both the progressive matrices and Mill Hill vocabulary tests. If there is a difference of 8 or more between his scores for the two tests, it is considered a significant discrepancy. *Table II* shows those results where there were significant discrepancies (8 or greater) between the two scores.

In the control group the discrepancies are divided almost equally between those with progressive matrices scores greater and less than Mill Hill vocabulary scores. In the cleft group, however, there are four times as many with vocabulary deficiencies as would be expected. On statistical analysis using Fisher's exact probability test this is shown to be not significant (P=0·137) but it does suggest the need for further investigation.

The relationship in the cleft group between speech grading, progressive matrices, and Mill Hill vocabulary scores was examined. On statistical analysis there was no significant association between speech and matrices (χ^2= 7·3449, P>0·3) but there was a significant relationship between speech and vocabulary and this is shown in *Table III*.

Table III.—Relationship Between Vocabulary and Speech Grading in Forty Cleft-palate Patients

Speech Grading	Mill Hill Vocabulary Grading					Total No. of Patients
	I	II	III	IV	V	
1	0	3	5	2	1	11
2	1	1	12	3	0	17
3	0	0	4	8	0	12
Total No. of Patients	1	4	21	13	1	40

Statistical analysis: χ^2=16·9197; d.f.=8; P<0·05

Table III shows that in the cleft-palate group the speech grading is associated with the Mill Hill vocabulary score. This is a statistically significant result. Thus it appears that cleft-palate adults have a poorer vocabulary when their speech is less intelligible and this is unrelated to their intellectual capacity, which is not significantly different from the control group.

SUMMARY

A group of 40 adult patients with palatal clefts was examined. Their intellectual capacity was assessed using both Raven's progressive matrices and the Mill Hill vocabulary scale. The control group consisted of 21 adults matched with the cleft group by age and who had similarly spent long periods in hospital during childhood.

Taken as a whole the intellectual capacity of the cleft group appeared to be not significantly different from the control group, nor was there a significant difference in vocabulary for the two groups. However, when the cleft-palate group was examined, it was found that those patients with poorer speech had the poorer vocabularies, which was unrelated to their intellectual capacity.

Acknowledgements

I am deeply indebted to Dr. R. H. Hetherington Senior Lecturer in Clinical Psychology at Liverpool University, for much invaluable advice and his assistance with the interpretation of the results, to Mrs. A. Donaldson and Mrs. J. Grimwade for their kind help with speech assessments, and to my wife for much painstaking help. Also I am grateful to Professor Roaf and Mr. John Monk, of the Orthopaedic Department, Liverpool University, for permission to use their patients as the control group in this study.

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DISCUSSION

The Chairman (Dr. J. S. Beresford) asked whether Mr. Lovius thought that cleft-palate folk only used words they could use comfortably and not the others, and whether their vocabulary would be greater if they had a written test.

Mr. Lovius answered that he thought cleft-palate folk did not only use words they could use comfortably. Their vocabulary had been tested in writing.

Mr. D. G. Huggins asked whether, on the basis that the intelligence of the cleft-palate patients was the same as that of the controls, Mr. Lovius felt that the environment of the families, the size of the families, the schools that they attended, and the amount of speech therapy received had any effect on their vocabulary.

Mr. Lovius replied that he felt all these factors could have an effect on the vocabulary of the cleft-palate patients.

Mr. L. H. Russell asked whether any of the patients showed signs of middle-ear deafness, which could severely inhibit vocabulary performance.

Mr. Lovius said that some of the patients did show signs of deafness. One of them was excluded from the testing because of this. The small amounts of hearing loss had not appeared to cause any alteration to the findings.

Mr. H. Lester asked at which tape speed the recordings had been made and were being replayed, as there appeared to be some distortion and lack of upper frequency response.

Mr. Lovius said that a very high quality Tandberg recorder had been used. The recording used to demonstrate the speech categories had been transcribed from $7\frac{1}{2}$ in. to $3\frac{3}{4}$ in. per sec. for playing at the meeting.

A vote of thanks to the speaker, proposed by the Chairman, was carried by acclamation.

THE CORRECTION OF CANINE AND PREMOLAR ROTATIONS

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THIS paper describes some of the methods available to the orthodontist for the correction and retention of canine and premolar rotations. These methods are presented to describe some currently used techniques.

The use of removable appliances for the correction of the rotations will not be discussed, as such appliances would be difficult to use, and are not as efficient as the application of a fixed band to a rotated tooth. The methods described involve the use of fixed-removable, labiolingual, or full multiband appliances with Ripple, Begg, or Edgewise brackets.

A B

Fig. 1.—A, Lingual button and lingual cleat welded onto the lingual surface of the band. B, An Alastik stretched between the first molar and premolar.

PURPOSE OF CORRECTING ROTATIONS

Many rotations are compatible with dental health (Orton, 1965), thus the purpose of correcting a rotation either stems from aesthetic needs or as part of a general treatment plan in attempting to produce a 'normal' or acceptable occlusion. This applies equally to the correction of canine and premolar rotations. The canine being the last tooth in its series to erupt may frequently be displaced and rotated as a result of crowding. The upper first premolar may sometimes be mesiolabially rotated to show its palatal cusp; this is frequently unaesthetic when the premolar is in the canine position. Both maxillary and mandibular second premolars are often rotated, and the correction of these rotations may not only produce a better occlusion but may also provide a little extra space necessary for the alinement of other teeth.

PRINCIPLES OF CORRECTING ROTATIONS

Of all the orthodontic tooth movements which may be performed, the rotation of a tooth around its long axis is one in which it is most necessary to make use of a fixed band both for control during movement and for the post-treatment retention of the rotation.

It is advisable where possible to make use of reciprocal forces to correct a rotation. This is a mechanically sound principle and also helps to control the tooth either by keeping it in the line of the arch or by bringing it into the line of the arch as a resultant of a simultaneously applied lingual and buccal force. The effect of the reciprocal forces is to provide a couple which reduces the tendency of excessive buccal and lingual movement; for example, in the simple form of rotation correction such as the use of a

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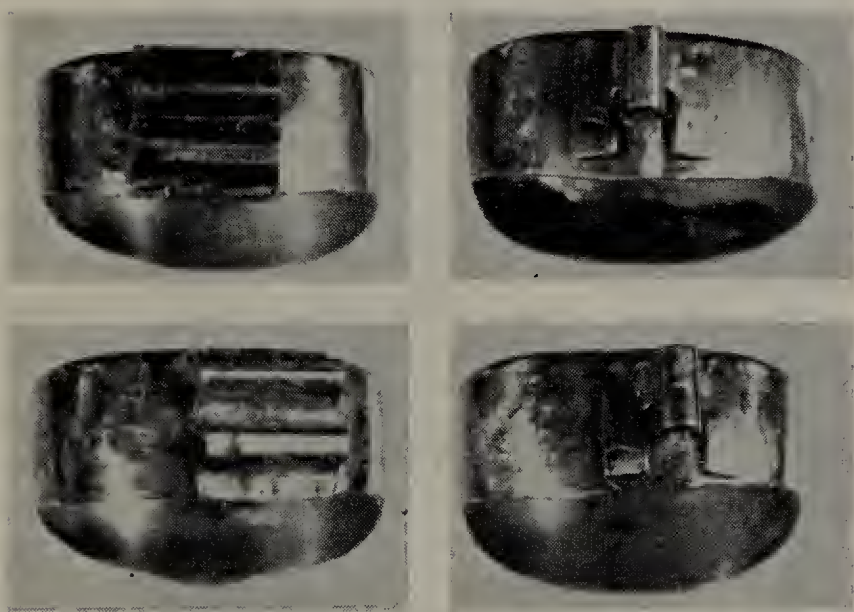
‘ whip ’ where the tooth is not held in the line of the arch, the resultant force tends to displace the tooth buccally as well as correcting the rotation. The use of additional palatal or lingual attachments, for the production of a reciprocal force, has been simplified with the introduction of the



A B

Fig. 2.—A, Ripple bracket. B, High flange Begg bracket. *Above*, Welded onto the centre of the band. *Below*, Both are in the offset position.

preformed lingual button or lingual cleat (*Fig*. 1). These are simply welded onto the band, obviating the need to construct a wire hook which has to be soldered or welded to the band.

The question of whether a rotated tooth should be merely alined or over-rotated does not yet seem to have been resolved, although the author favours over-correction of the rotation. The degree of relapse, however, probably depends more on the duration of the retention period than on the degree of over-correction of the rotation. When welding brackets onto the bands of rotated teeth, it is a good principle to offset the bracket to oppose the rotation (*Fig*. 2). This allows the use of an archwire nearer to an ideal arch form and makes over-correction easier. The offset reduces the need to activate the arch wire, and in the later stages of tooth alinement to hold the tooth in the over-corrected position without making an allowance for it in the arch wire.

FIXED-REMOVABLE APPLIANCES

The simplest method of correcting a rotation is by means of a ‘ whip ’ (*Fig*. 3). With the advent of the new range of high-tensile wires (German and Australian), the whip has become even more effective as it is not so easily distorted. The whip is probably most easily applied to a band with a Ripple bracket or a pin-and-tube attachment, although modified forms of a whip may be applied to Begg or Edgewise brackets. The length of a whip should be a minimum of 2 tooth units but not excessive or else it may be damaged in either the occlusal or lateral plane. The thickness is usually 0·35–0·45 mm. which, together with the degree of activation, should produce a

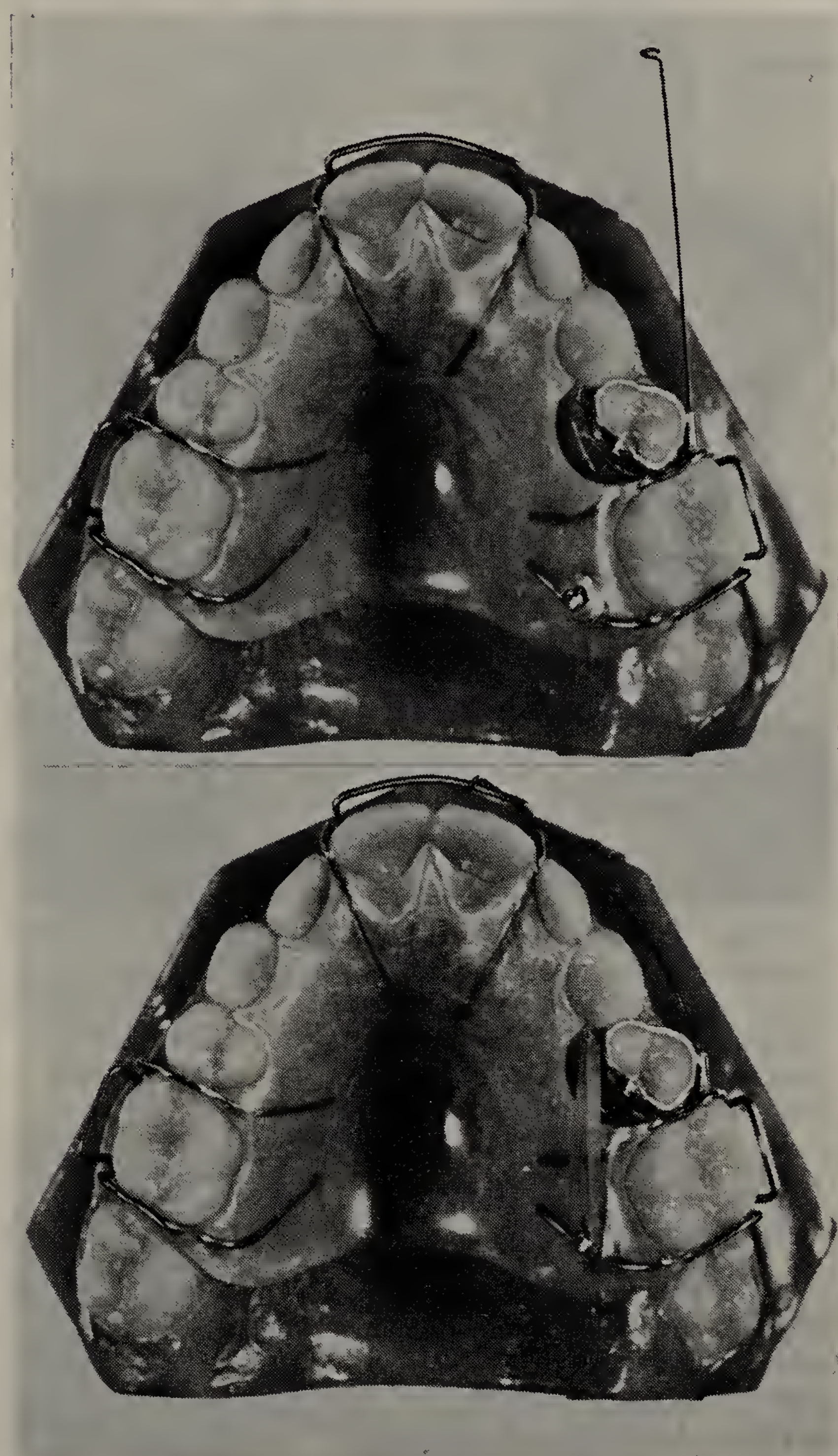


Fig. 3.—Appliance to correct a mesiobuccal rotation of $\underline{|5}$. A removable appliance with a double anterior Adams crib to take the whip. The $\underline{|5}$ is banded with a Ripple bracket and lingual cleat; a 0·4-mm. whip is inserted through the Ripple bracket. A small latex is applied from the lingual cleat to a lingual button which has been cured into the removable appliance. This provides a reciprocal force. *Above*, Passive position. *Below*, Active position.

light force. The free end of the whip should not contact the buccal surfaces of any of the intermediate teeth as these may act as a fulcrum and displace the tooth buccally. The free end of the whip is hooked onto a conveniently placed crib of a removable appliance; for canine and

premolar rotations a crib on the incisors or the first molar crib, depending on the type of rotation, is often convenient.

The use of reciprocal forces with a whip increases the mechanical efficiency of the tooth movement and makes for quicker correction of the rotation. The crown form of the premolar lends itself particularly well to the use of reciprocal forces. These may be applied by adding a lingual button or lingual cleat and applying traction by means of latex bands.

Fig. 4.—Labiolingual type of appliance to correct 3|3 rotations. The lingual arch is 0·9 mm. and the buccal archwire is 0·45 mm. to prevent distortion in the unsupported buccal and labial segments. An elastic ligature has been applied from lingual cleats on 3|3 to the archwire.

LABIOLINGUAL APPLIANCES

An adaptation of the labiolingual technique may be used particularly for the correction of canine rotations. A 0·9-mm. lingual or palatal arch is soldered to the first molar bands to stabilize these teeth; 0·9-mm. buccal tubes are welded to the bands and from these a 0·45-mm. archwire may be constructed to correct the rotations.

The case illustrated (*Fig.* 4) is one with a mesiobuccal rotation on 3| and mesiolingual rotation on |3; 4|4 were extracted as part of the treatment plan. Teeth 3|3 were banded with Begg brackets offset to counter the rotations, cleats being applied lingually. The 0·45-mm. archwire was inserted with third-power bends mesial and distal to the canines and an elastic ligature was applied from the cleat to the archwire. The effect of this was to apply a reciprocal force to correct the rotation and later to encourage over-rotation. From the |3 the elastic ligature was applied interproximally, which in fact serves two purposes, for as well as helping to provide a rotational force it acts as a separator to free the contact with the lateral incisor.

One advantage of this particular technique, is that it may be used where it has been decided not to band the rest of the arch.

FIXED APPLIANCES

In the fully banded appliance a whip or some modification may be used to correct a rotation. Normally, the means of correcting the rotation is incorporated in the main archwire, but occasionally it is useful to add a whip auxiliary without disturbing the rest of the appliance. In *Fig.* 5A a 0·4-mm. whip has been applied to a ripple bracket to correct a mesiobuccal rotation of |5. In this typodont excercise no lingual attachment for reciprocal forces was applied.

In the Begg technique a 0·35-mm. uprighting spring may be applied to a Begg bracket to act as a whip (*Fig.* 5B). Again a mesiobuccal rotation on the |5 is illustrated: the main archwire is ligated to the bracket with a 0·25-mm. soft ligature and the uprighting spring is inserted from the gingival aspect through the vertical slot and turned over occlusally, so that the free arm of the spring lies at about 40° to the mesial of the main archwire. When the spring is hooked onto the archwire, its action is the same as that of a whip.

A standard method of correcting a rotation with fixed appliances is by incorporating two third-power bends in the archwire (*Fig.* 6). The archwire is usually 0·4 mm. thick and the third-power bends allow for flexibility in the region of the rotated tooth. Where Begg brackets are used this usually allows the archwire to be pinned in at the first visit. With a more severe rotation in which it is not possible to fully engage the archwire, it may be ligated to the bracket in the first instance.

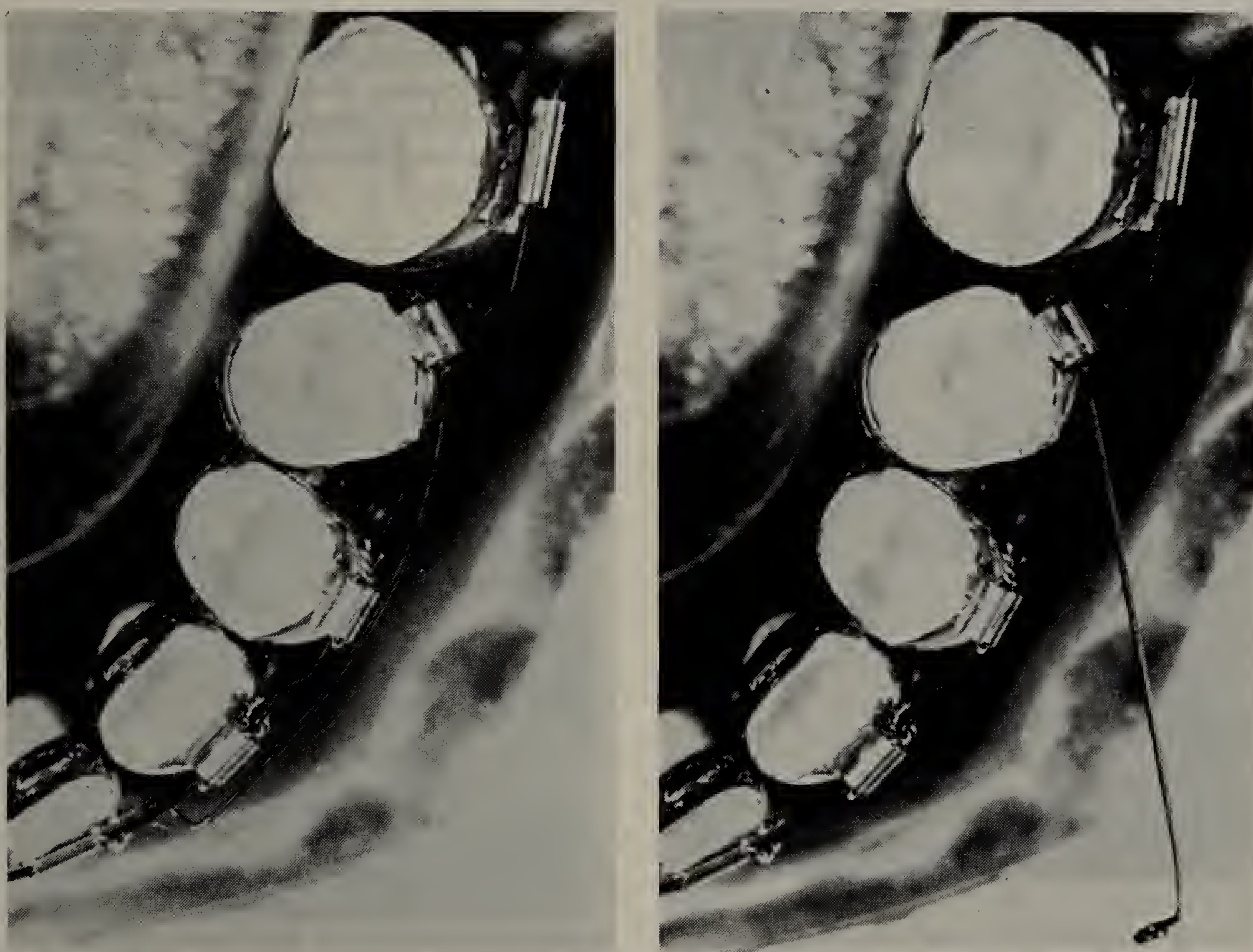
The wide or Siamese Edgewise brackets are particularly useful for the correction of rotations (*Fig.* 7). In conjunction with two third-power bends in the archwire, a greater length may be engaged into the bracket so that the mechanical efficiency of the rotation correction is increased.

With the introduction of the Alastik force modules or Ortholastiks which can be used in place of a ligature wire to secure the archwire, a flexible system may be applied. Here as the rotation is gradually corrected the Alastik module engages the archwire into the bracket. If there is a mild rotation and a wide or Siamese edgewise bracket is used, the rotation may be corrected by applying an Alastik module from the bracket to a plain archwire (*see* 3|, *Fig.* 7).

Although Alastik modules may be used entirely to replace wire ligatures using round archwires, after the correction of a rotation it is advisable to use wire ligation to engage the tooth fully into the archwire, for retention purposes.

AUXILIARY ATTACHMENTS

The use of the lingual button or lingual cleat has been illustrated in some of the cases (*Figs.* 1, 3, 6, and 7). In most instances it has been used to help produce a palatal rotational force. Its use with an upper canine is often limited by the occlusion.



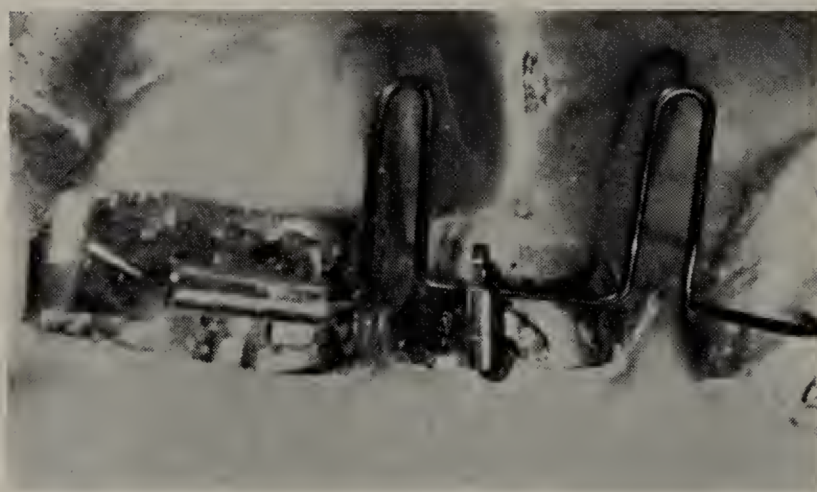
A

B

Fig. 5.—A, A mesiobuccal rotation of $\overline{|5}$ with a 0·4-mm. whip applied from a Ripple bracket to the main archwire, in the active (*left*) and passive (*right*) positions. B, 0·35-mm. uprighting spring applied to correct a mesiobuccal rotation on $\overline{|5}$. The occlusal view shows how the end of the spring is turned down. The side view shows the uprighting spring engaged into the main archwire.

Where there is a mesiobuccal rotation on a premolar the force applied from the lingual cleat to the lingual button on the first molar is not enough to cause any adverse rotation of the molar. A latex, elastic ligature or an Alastik chain may be applied to provide the force. Latex is probably the most efficient as it is renewed regularly by the patient, the elastic thread does not keep very clean but otherwise is effective, and the Alastik chain is most useful where patient co-operation is not too good.

In a mesiolingual rotation, an elastic ligature may be applied from a lingual cleat to the arch-wire on the mesial aspect. In this case, the cleat is particularly useful as opposed to a lingual button,



A

B

Fig. 6.—A mesiobuccal rotation 5| correction using Begg brackets. A, Side view showing the two third-power bends in the 0·4-mm. archwire. B, Occlusal view showing the 0·4-mm. archwire engaged into the 5| bracket. There is a lingual button on 6| and lingual cleat on 5| with a small latex to produce a reciprocal force.

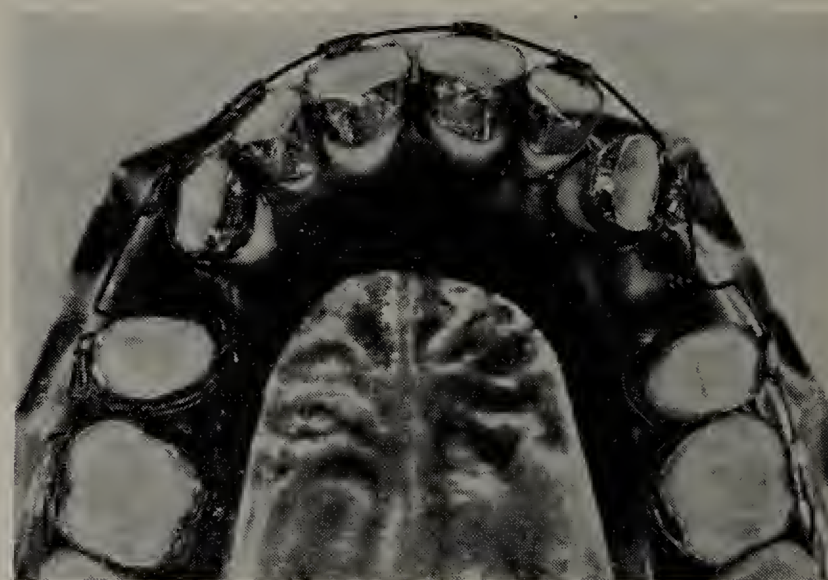
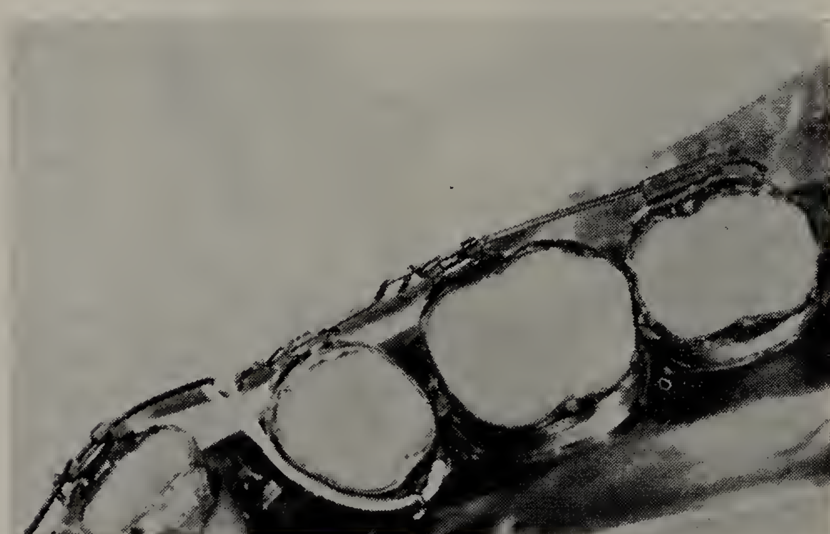


Fig. 7.—Typodont exercise with rotation on 5 3 | 3, using a 0·4-mm. archwire secured by Alastiks. The 5| has a buccal rotation to be corrected with a wide Edgewise bracket secured to the archwire by an Alastik partly engaged. There is also an Alastik chain providing a reciprocal force |56. A mild mesiobuccal rotation of the 3| is treated with twin Siamese brackets partly engaged into a straight archwire by an Alastik. The |3 has a mesiobuccal rotation which is treated with twin Siamese brackets with two third-power bends in the archwire secured by two Alastiks for flexibility.



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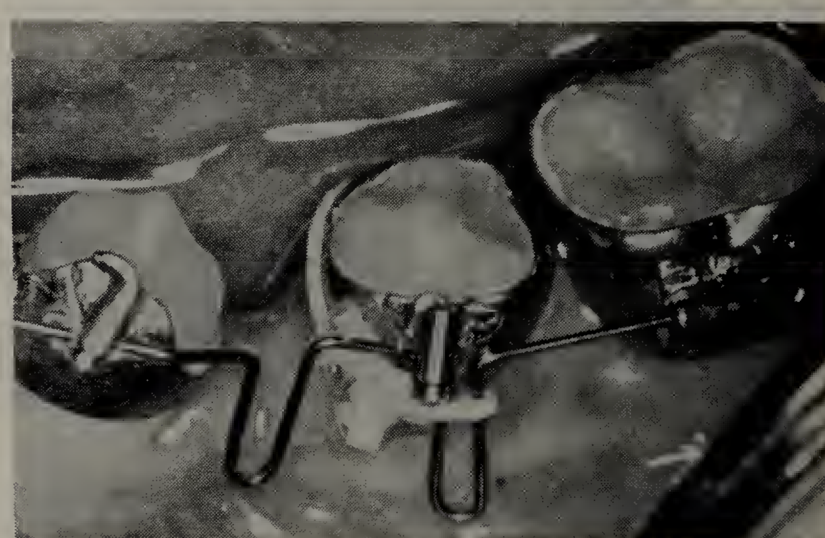

B

Fig. 8.—A, Mesiolingual rotation of 5|. There is an elastic thread from the lingual cleat to the region of a single third-power bend on the main 0·4-mm. archwire. The picture shows how the elastic thread is prevented from lifting up by the mesial arm of the cleat. When the rotation is not severe a single third-power bend is often sufficient to allow engagement of the archwire into the bracket. B, Mesiolingual rotation of |5 showing the elastic thread secured to the distal third-power bend to prevent it lifting up over the occlusal surface.

as the mesial arm of the cleat prevents the elastic thread from slipping up to lie directly across the tooth (*Fig.* 8A). Another method of preventing the elastic ligature from slipping up over the occlusal surface is to carry it underneath the archwire to the distal third-power bend (*Fig.* 8B).

RETENTION

Many rotations are retained by the main archwire or a sectional arch as part of the general treatment plan. Sometimes it is necessary to retain an individual tooth for a longer period than the general retention period, or because it is the only rotation. In these cases a band and spur is very useful (*Fig.* 9). A 0·7-mm. soft stainless-steel wire is welded to the buccal and lingual aspects of the band to counter the rotation; the spurs are then contoured to the adjacent teeth and finally soldered.

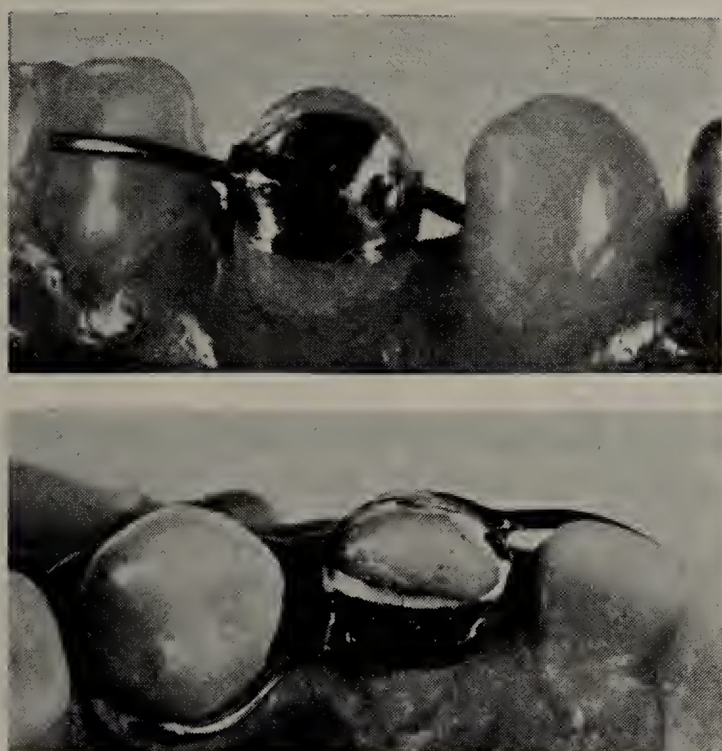

Fig. 9.—Band and spurs to retain mesiolingual rotation on $\overline{3}|$. The spurs are 0·7-mm. soft stainless-steel wire welded and soldered after contouring.

Another method is to band the adjacent tooth and the de-rotated tooth and solder these bands together (*Fig.* 10). This may be carried out by an indirect or direct technique. In the indirect technique an overall impression is taken of the two bands so that they may be inserted in the impression and later soldered together on a plaster model. In the direct technique, the bands are located by means of a piece of 3·5-mm. stainless-steel tape temporarily tack-welded to the buccal aspects of the bands so that they are passive. The bands are carefully removed from the teeth and solder is flushed through the contact point. The steel-tape positioner is then cut and removed by stoning. The original rotation is shown in *Fig.* 3.

The ideal duration of the retention period does not yet appear to have been resolved, although a period of at least 6 months with fixed retainers seems to be necessary.

In discussing the relapse of rotations, Reitan's (1958) work on dogs suggests that the relapse of the de-rotated tooth is caused primarily by a contraction of displaced gingival fibres and other supra-alveolar soft-tissue structures. Recent work by Edwards (1970) on young patients seems to support the idea that trans-section of all fibrous attachments to a depth of 3 mm. below the crest of alveolar bone reduces the necessary retention period and prevents relapse of de-rotated teeth.

Fig. 10.—Bands on $\underline{|34}$ soldered together to retain a corrected mesiobuccal rotation on $\underline{|4}$.

SUMMARY

A short discussion on the purpose of correcting canine and premolar rotations and the principles involved in their correction has been presented. The use of additional attachments for the production of reciprocal forces has been described.

Some methods for correcting canine and premolar rotations have been shown, these include fixed-removable, labiolingual, and full multiband techniques. Two methods of retention are described, together with a short comment on duration of retention, and trans-section of the superficial gingival fibres.

Acknowledgements

I would like to thank Mr. J. S. Rose and Dr. P. Vig for their encouragement and advice in the preparation of this paper, Mr. M. S. E. Gould for allowing me to show one of his cases, Mr. H. Haringman for the preparation of the models, and Mr. P. Jacobs and Miss V. Shaw of the Photographic Department of the Dental Institute.

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RECENT TRENDS IN THE EARLY TREATMENT OF CLEFT LIP AND PALATE

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INTRODUCTION

It is now generally accepted that the treatment of infants with clefts will involve several specialists grouped together to form a ' team '. It is not, however, very long since this approach was developed. It was pioneered in Pennsylvania by Dr. H. K. Cooper who was responsible for the creation of the Lancaster Cleft Palate Clinic.

Stark (1965), commenting on the recent improvements in cleft-palate treatment, says: ' but the longest strides have come since the Second World War. They can be laid at the door of increased skill perfected by the plastic surgeons in and after the war as well as to the concept of the interdependence and interdigitation of disparate skills of many specialists working together as a team to make normal a child with this most complex anomaly.'

The surgical developments are dealt with in the appropriate textbooks and journals (Jolleys, 1952, 1954; Millard, 1964, 1968; Craig, 1967) to which those wishing further details are referred.

Broadly speaking there are two different approaches followed in the treatment of cleft infants in the various centres throughout the world. These are: (1) Surgical repair followed by orthodontic care, and (2) Presurgical orthodontics (or oral orthopaedics) followed chronologically by surgical repair.

The second approach was introduced by Kjellgren (1949) and McNeil (1950) almost simultaneously in different parts of Europe—a not uncommon phenomenon. McNeil's approach has since been taken up in many centres, one of its best known advocates is Burston (1958).

In this particular paper it is proposed to limit the contents to a consideration of the developments of the past 20 years, i.e., since the introduction or more properly the re-introduction of presurgical alinement as Griswold and Sage (1966) have reported that Louis (a French surgeon) advocated presurgical treatment in 1768, as did Chaussier in 1776, in respect of patients with bilateral clefts and prominent premaxillae.

By no means all workers in the field of cleft lip and palate are agreed that presurgical oral orthopaedics is either necessary or beneficial. It seems to the writer that the burden of proof lies with those who advise the introduction of a new technique or the adaptation or modification of an older method.

At this juncture I would like to outline the contents of this communication. These are:—

1. A comment on presurgical oral orthopaedics.
2. A report on a study of early bone-grafting.
3. Records and recording methods.
4. The changes produced by presurgical oral orthopaedic treatment.
5. Case analysis and treatment planning.
6. General conclusions.

PRESURGICAL ORAL ORTHOPAEDICS

Presurgical oral orthopaedics was, as mentioned, pioneered in this country by McNeil and is distinct from early bone-grafting. The two procedures are *not* synonymous in spite of the assertions of some workers. The period from 1950 to 1960 was the decade of presurgical oral orthopaedics and quite a number of papers were published on the subject by McNeil (1950, 1954, 1956, 1964), Burston (1958), Derichsweiler (1958), and others during this time.

The majority of the papers published so far on presurgical treatment have presented the author's opinions and, in some instances to a limited extent, their proposed method of patient care. Latham (1969a,b), from the study of human material, has provided evidence of the nature of the original malformation stressing that the malrelationships found at birth are the result of displacements caused by the nasal septum acting through the septopremaxillary ligament. Other writers have emphasized the part that the divided musculature plays in producing the deformity. It would seem not unreasonable to consider that

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both elements (skeletal and muscular) work together to produce the deformity which is present. The work of Atherton (1967) supports the view that presurgical oral orthopaedics is based on sound principles. Huddart, MacCauley, and Davis (1969) are among the small number of workers who have presented the results obtained in cases treated by presurgical methods, while Pruzansky and Aduss (1964, 1967) and Handelman and Pruzansky (1968) have published data from patients treated surgically without any previous orthodontics which can be used to compare with presurgical results. In 1964 the first international symposium on early treatment was held in Zurich organized by Professor Hotz, the proceedings of this symposium have since been published (Hotz, 1964). In 1966 Pruzansky published a very critical review of the proceedings.

The writer's opinion is that very little has yet been given on aspects of treatment planning for the early orthodontic care of cleft patients, and remarkably few results have been published which would allow a comparison to be made between the two approaches, presurgical and postsurgical orthodontics.

A study of the literature on presurgical oral orthopaedics reveals that the following claims have been made on its behalf:—

1. It would facilitate the infant's feeding.
2. Repositioning of the jaw and lip segments facilitated lip and palate surgery.
3. It provided early reassurance to the parents.
4. It allowed improved occlusal developments.

These are quite bold claims and, as indicated, the writer's opinion is that the onus of proof lies with those practising the new techniques either alone or working in conjunction with another centre who follow alternative methods. It would appear logical that treatment carried out should follow a treatment plan devised after consultation with surgical colleagues and only after the case has been analysed utilizing the patient's records and the pool of knowledge presently available. If this is done and the results obtained are critically examined and the lessons learnt adopted, then further progress in terms of improved occlusions may be expected.

EARLY BONE-GRAFTING

Probably the most significant suggestion in the 1960s was that early bone-grafting might well improve the results achieved by preventing the occurrence of a cross-bite in the deciduous canine area on the cleft side, allowing teeth to develop and migrate through the grafted bone, and providing support for the base of the alar cartilage. The first workers to propose early bone-grafting were Johansen and Nordin (1955) and Schmid (1955). A few years later there was considerable interest in the idea in the United States as shown by the publications of Brauer and Cronin (1964), Pickrell, Quinn, and Massengill (1968), and others. Some writers advocated the insertion of bone at the time of the lip and anterior palate repair (' primary ' grafting) while others preferred to prepare a bed for the graft which was inserted at a subsequent operation.

The writer and his surgical colleague, Mr. Ambrose Jolleys, were of the opinion that early bone-grafting might well prove to be helpful and therefore decided to undertake a controlled study. The details of this study including the statistical methods employed are given fully elsewhere (Robertson and Jolleys, 1968; Robertson, 1969), but I feel it would be helpful to present the results here. Two groups, each of 14 newborn infants with complete clefts of the lip and palate, were treated simultaneously with treatments similar in all respects except one, the insertion in the experimental group of rib bone-grafts at the age of 15 months. The infants were ' paired ' at the outset on the basis of the type and degree of deformity and carefully recorded by means of standardized photographs, record models, cephalometric and occlusal radiographs, and written records. A comparison of the results achieved in the two groups of children at 5 years showed that the results were significantly better in the control (ungrafted) children. The results will be presented photographically.

1. Photographs

Serial photographs of 2 patients, one from the experimental group, the other from the control group, are shown (*Figs.* 1, 2). It is recognized that appearance is an amalgam of the bony relationship covered by a mobile soft-tissue drape of variable thickness and activated by the muscles of expression and mastication. A faulty basal relationship may therefore be partially masked by the soft tissues. Facial photographs of each of the patients were examined by a medical practitioner who was not informed which of each of the pairs had been grafted. The grafted children were reported as having a flattening of the upper lip area in a significant number (at a level of less than 0·1).

2. Radiographs

a. Cephalometric films

The serial films of the sedated infants were traced by an experienced tracer using Downs' (1948) method of analysis for the lateral views and Harvold's for the frontal views (Harvold, 1954). Double determinations of the results were done, the tracer being unaware of his previous results and the results were reproduced to within $\pm 0{\cdot}5°$.

The anteroposterior dental base relationship remained constant in the controls (within the limits of error of the experimental technique). In the experimental (grafted) group, however, the dental base relationship deteriorated from

satisfactory to Class 3 of varying severity (*Figs.* 3, 4). The results were significant at the level of 0·01 per cent (Robertson, 1969).

No significant differences could be detected on the frontal headplates.

b. Occlusal radiographs

Serial occlusal radiographs of the grafted infants showed that most of the bone was resorbed with the passing of the years and at the fifth year only a simple strut joined the two segments (*Fig.* 5).

3. Record Models

The occlusion in the two groups was considered with regard to: (*a*) the incisor overjet, (*b*) the buccal segments relationship, and (*c*) the upper and lower arch size.

Fig. 1.—Serial photographs of a patient from the experimental (grafted) group, from birth to 5 years.

a. The incisor overjet reflected the underlying basal relationship. In the control (ungrafted) children there was a Class I incisor relationship while in the experimental (grafted) children the overjet was either reduced or moved into a reverse or Class III arrangement (*Fig*. 6). This was significant at a 0·02 per cent level (Robertson, 1969).

b. The presence of a bone-graft did not prevent the occurrence of cross-bite. In our series cross-bite was more prevalent in the experimental (grafted) series on both the cleft and non-cleft sides (*Fig*. 7) (Robertson, 1969).

c. The upper and lower arch sizes were measured using a planimeter on 1:1 photographs of the occlusal aspects of the models (Smith, 1967). The area of upper to lower expressed as a percentage was greater in each of the ungrafted children than the grafted member of the pair. The possibility of this occurring by chance is less than 0·02 per cent.

Pruzansky and Aduss (1967) have compared the results achieved at their unit in Chicago with those achieved elsewhere and concluded that early bone-grafting is not beneficial. Johansen (1965) announced that he was no longer carrying out early bone-grafting as he was dissatisfied with the results achieved. Pickrell, Quinn, and Massengill (1968) reported on a series of cases of primary bone-grafting carried out at ages from 2 to 6 months. They followed up 25 such infants annually over a period of 4 years and concluded:—

1. Bone-grafts in the maxilla did not increase in size with facial growth and development.
2. Teeth did not migrate and erupt through the grafts.
3. Grafts did not form a true alveolar process.
4. The orthopaedic effect of the bone-graft decreases as time progresses.

In the light of our own experimental work and the results published by other workers we are concentrating on attempts to improve the results obtained by presurgical oral orthopaedics and soft-tissue surgery.

RECORDING METHODS

The value of adequate records in routine orthodontic practice is well recognized and put into practice. The recording methods in our unit have been gradually improved and for some years it has been standard practice to take the following records (together with written notes of the condition):—

1. Upper and lower oriented study models from rubber-base impressions.

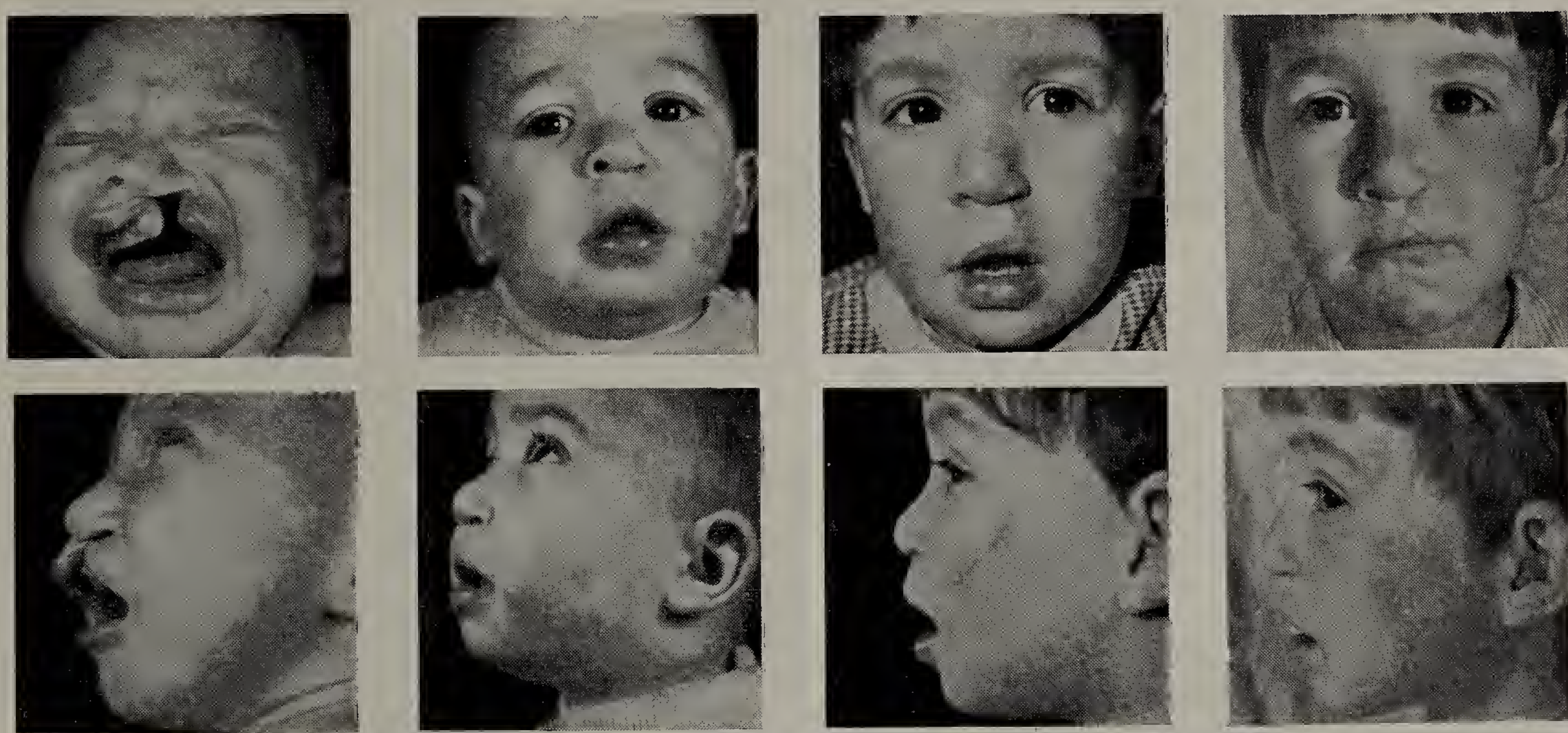


Fig. 2.—Serial photographs of a patient from the control (ungrafted) group, from birth to 5 years.

Fig. 3.—Lateral cephalometric head plate of a child from the control group at age 5 years.

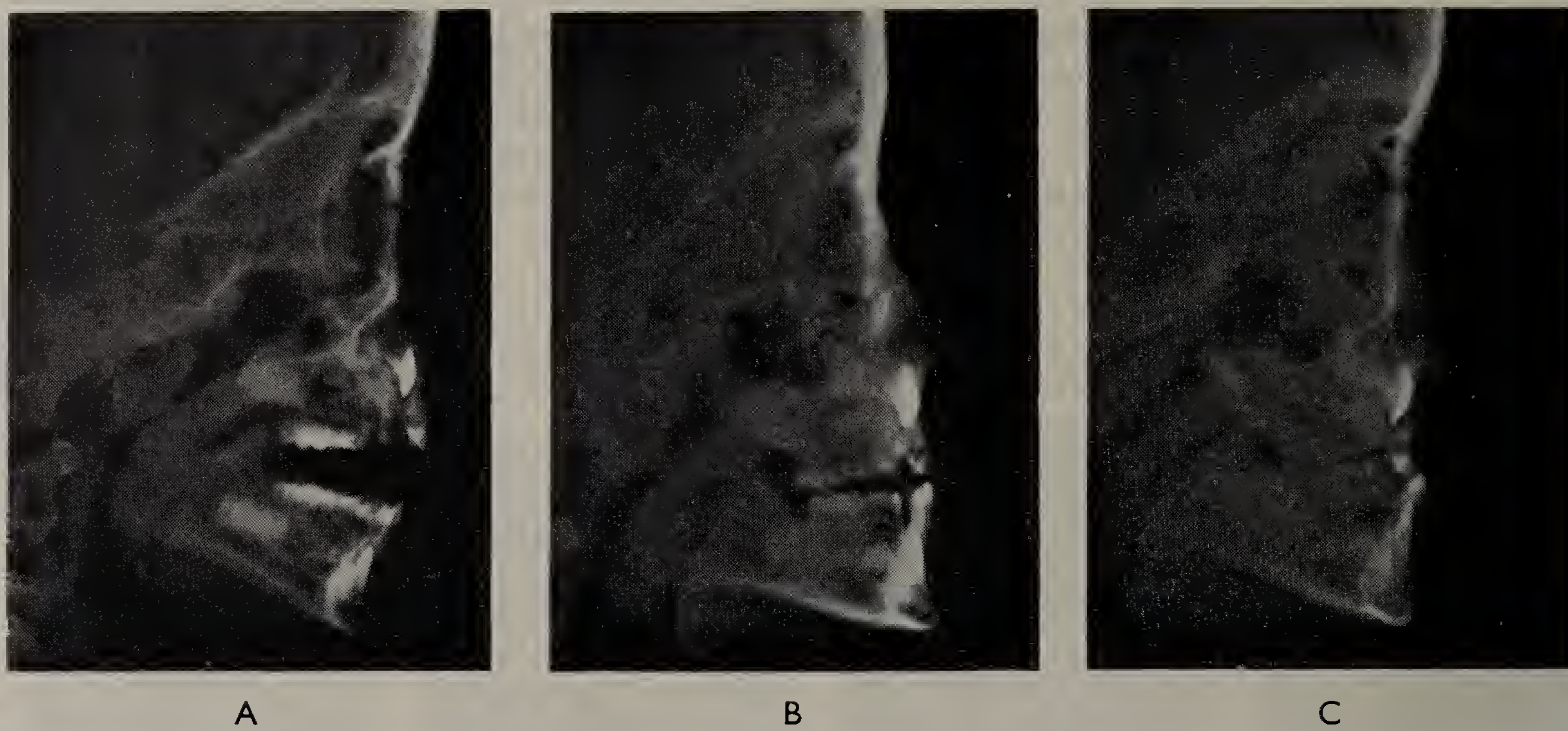


Fig. 4.—Serial lateral cephalometric headplates of a child from the experimental (grafted) group showing deterioration in dental base relationship from Class 1 (A) to Class 3 (B and C).

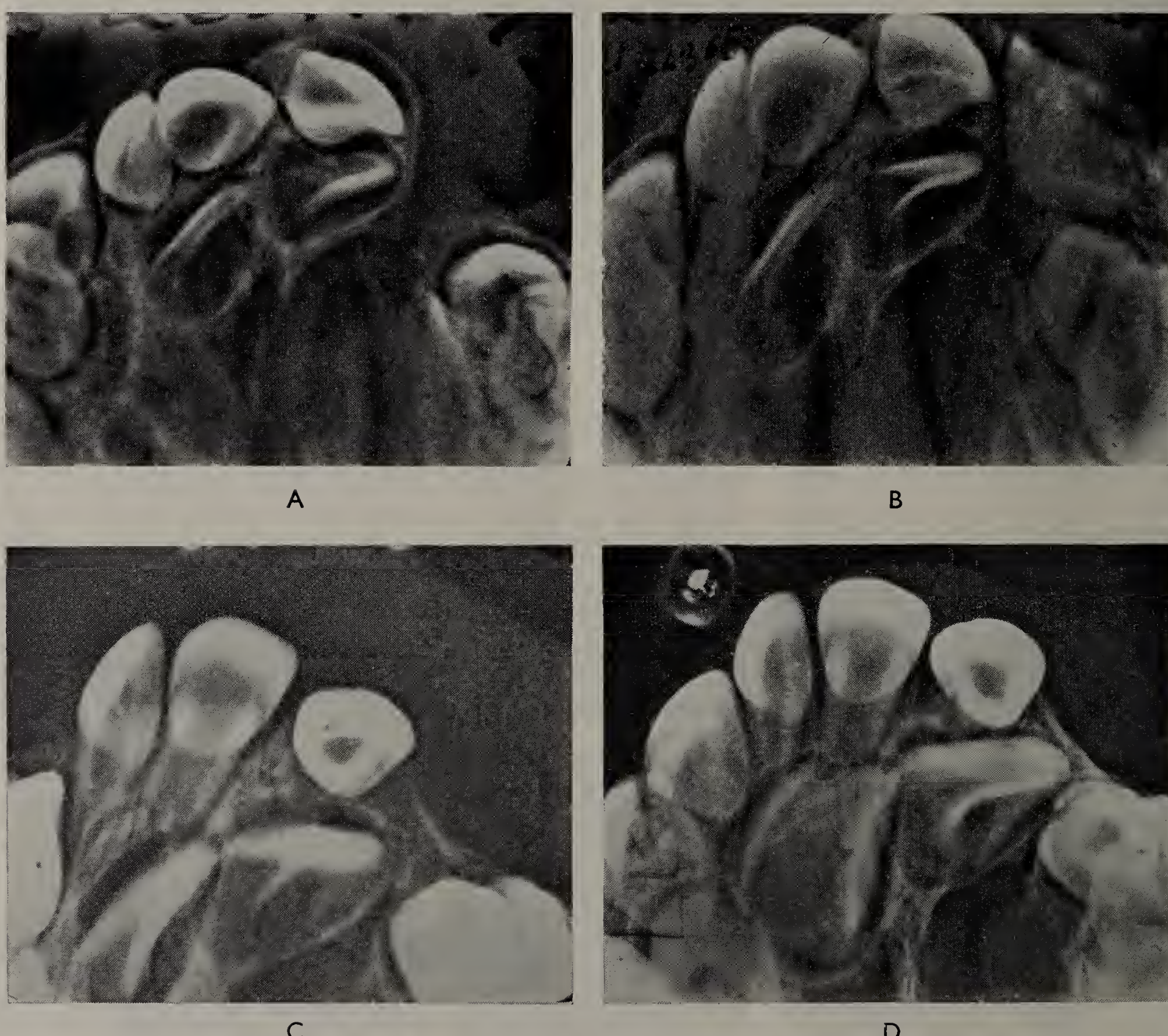
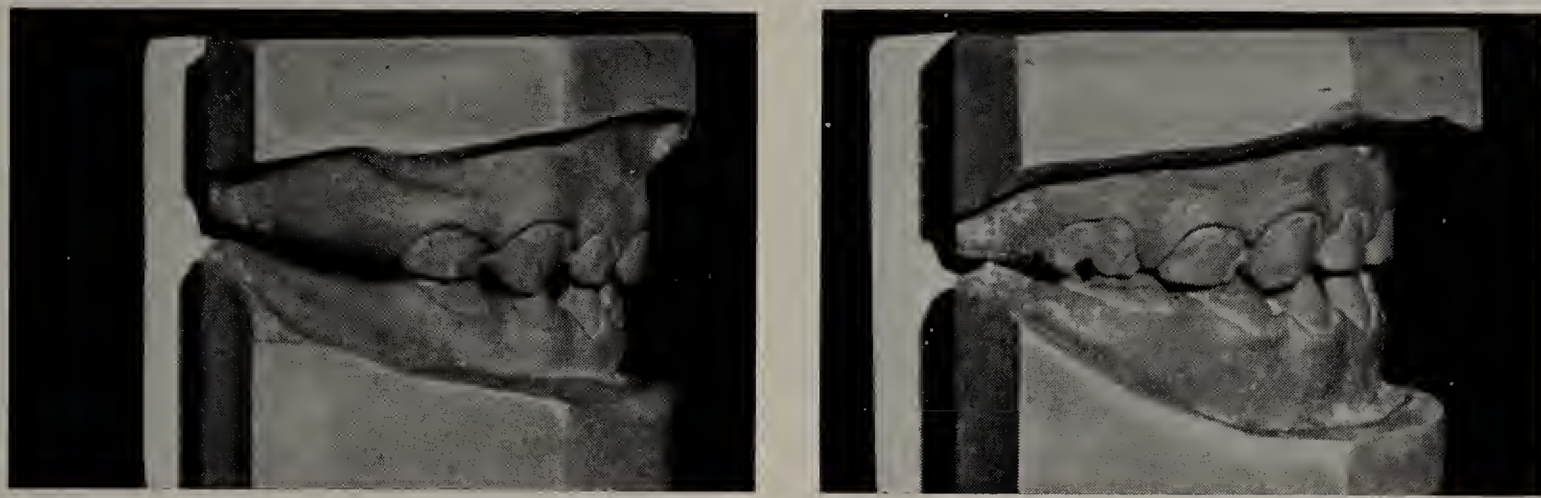
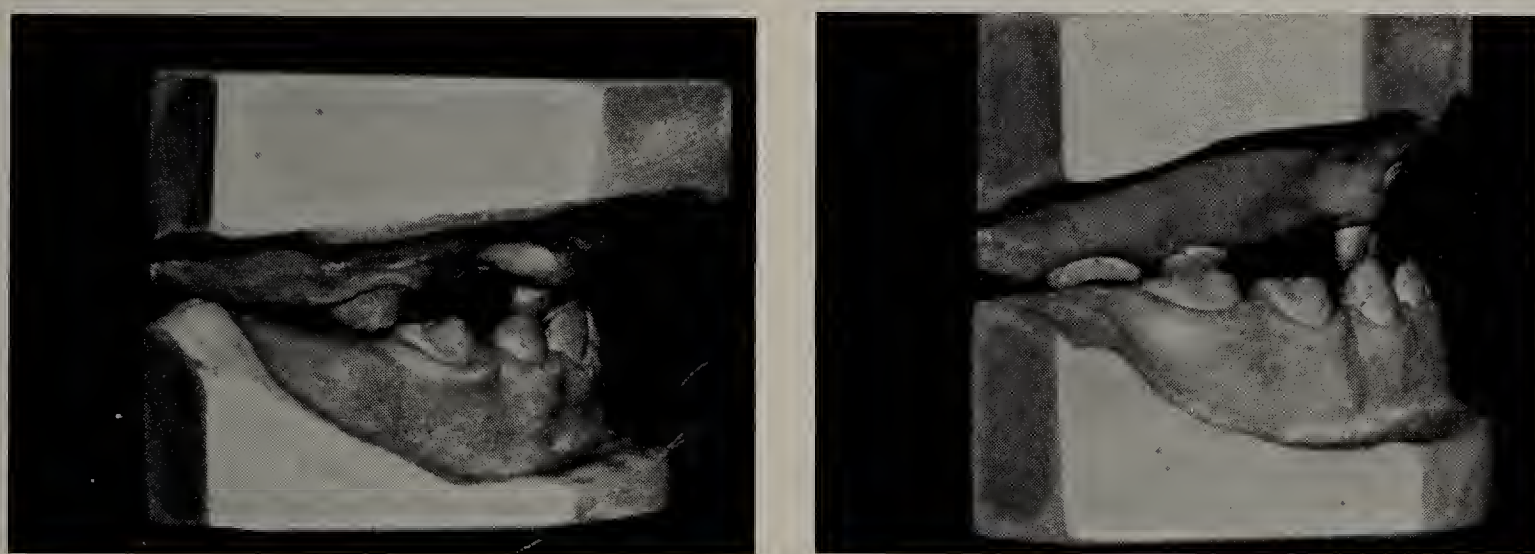


Fig. 5.—Serial occlusal radiographs of the cleft area of a child from the grafted group. A, After alinement and prior to grafting. B, Immediately after insertion of bone-graft. C, D, Slow progressive resorption of graft.



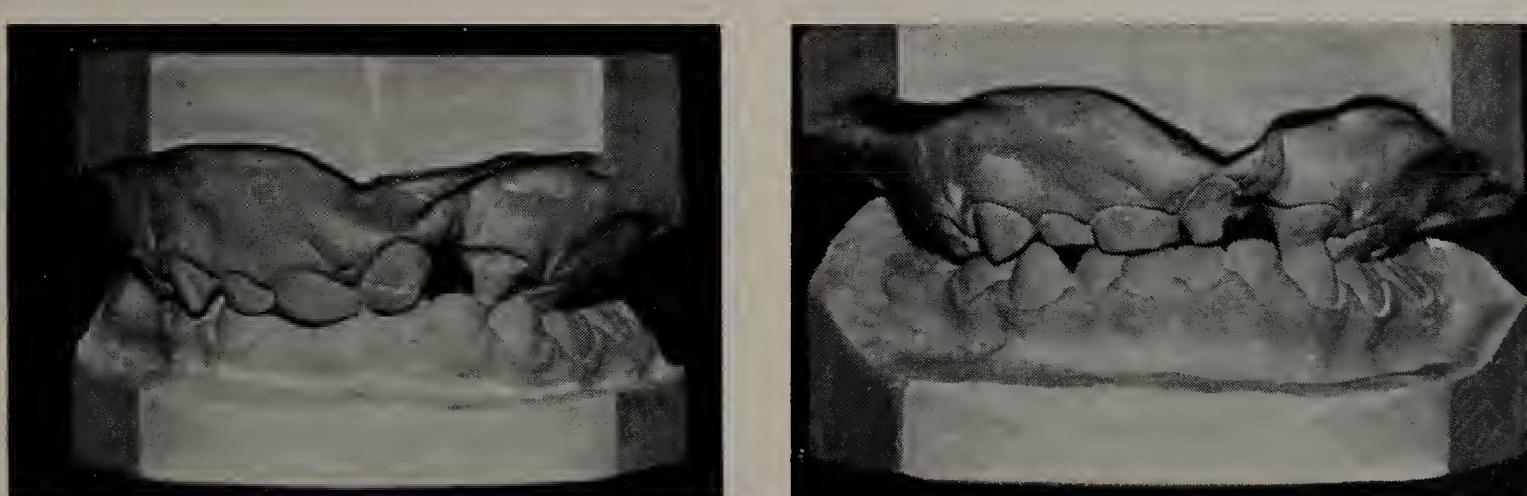
A



B

Fig. 6.—A, Lateral view of models of occlusion of a patient in the control group. B, Lateral view of models of occlusion of a patient in the experimental (grafted) group.

A



B

Fig. 7.—A, Anterior view of models of occlusion of a patient in the control group. B, Anterior view of models of occlusion of a patient in the experimental (grafted) group.

2. Facial and intra-oral photographs (standard views).

3. Lateral and frontal cephalometric radiographs and intra-oral occlusal radiographs.

The cephalometric films are made on sedated infants in a Wehner infants' cephalometer as designed by Pruzansky and Lis (1958). Before the initial headplates are made, tantalum implants are inserted in the upper and lower jaw after the method described by Björk (1955). The maxillary implants are inserted in the sites illustrated in *Fig*. 8.

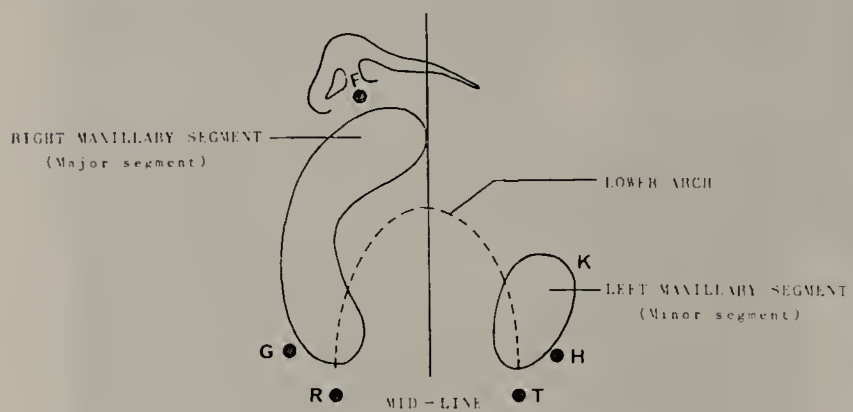


Fig. 8.—Shows the sites for insertion of tantalum implants in a patient with a unilateral cleft. (F, G, K, and H).

Each infant is recorded on admission, i.e., as soon after birth as practicable, at the third month (before surgery), during the twelfth month, and every year thereafter until the fifth, when records are taken every 2 years.

THE CHANGES PRODUCED BY PRESURGICAL ORAL ORTHOPAEDICS

Method

If progress is to be made with the technique of presurgical oral orthopaedics it is essential to determine precisely what may or may not be achieved by means of the methods used. To this end, a method of demonstrating change was outlined before the research meeting of this society (Robertson and Hilton, 1968) and a fuller report is published elsewhere (Robertson and Hilton, 1971). This involved the insertion of tantalum implants as described and taking frontal and lateral cephalometric radiographs on admission (immediately after birth) and again at the twelfth week. The implants may be regarded as fixed points within the individual jaws or segments of the jaws and the movement between the two films indicates the movements produced. The successive headplates may be traced, e.g., frontal headplate using Harvold's method, and the distance between the posterior maxillary implants before and after treatment recorded. Alternatively, and a more recent measure, logetronic radiographic duplicating equipment (*Fig*. 9) has been used, by which it is possible to produce two thin films which can be superimposed to show the changes directly.

Material

This has now been carried out on a group of 60 newborn infants. Forty with unilateral complete clefts and with displacement of jaw segments which were treated, and 10 with bilateral clefts with displacement of the segments. In the remaining group of 10 the cleft did not involve the alveolar ridge and as no presurgical movement of the segments was called for these have been used as controls.

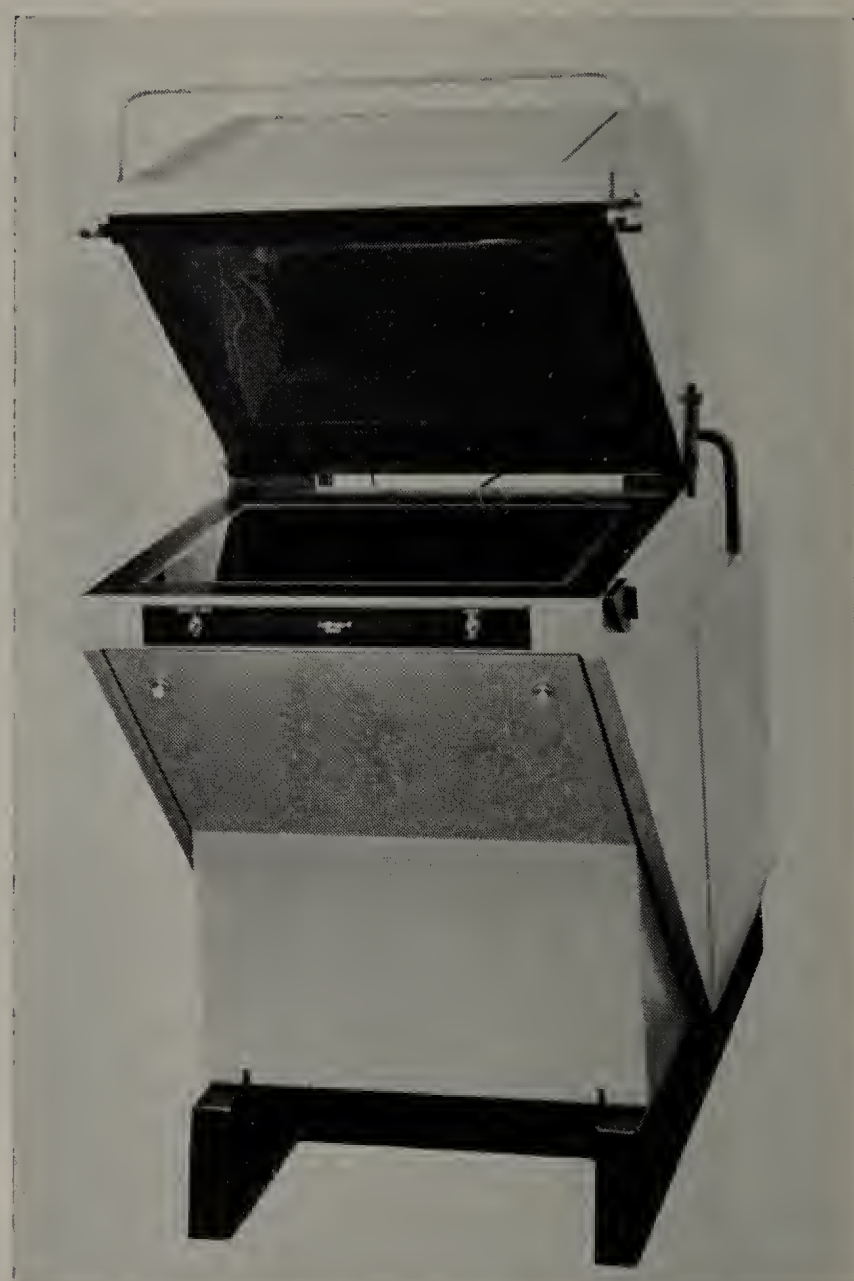


Fig. 9.—Logetronic radiographic duplicating machine.

Results

The tracings of the frontal and lateral cephalograms for each of the infants taken on admission and at 3 months were superimposed and examined. The frontal headplates were superimposed on FMT–FMT and the 'X' plane, the lateral headplates were superimposed on SN with 'S' points coincident. The findings are given for each of the three groups: (1) controls, (2) unilateral clefts, and (3) bilateral clefts.

1. *Controls* (*Incomplete Clefts*)

a. Frontal views

i. The distance between the posterior maxillary implants remained the same.

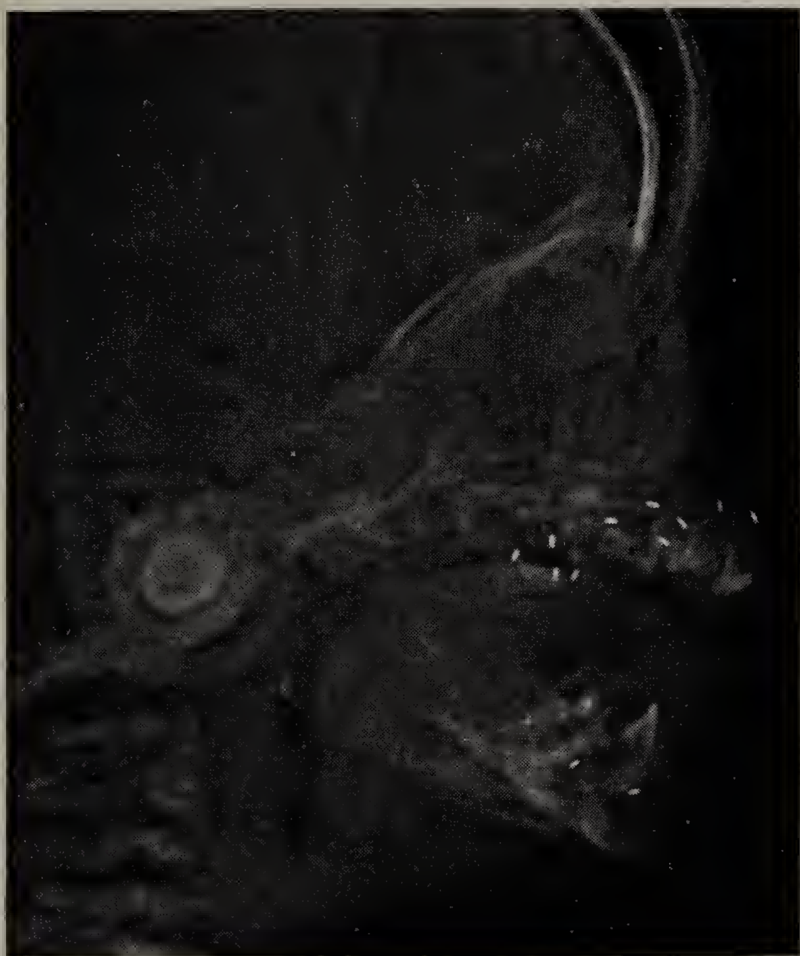


Fig. 10.—Superimposed cephalometric headplates of an infant with a bilateral incomplete cleft on admission and at age 12 weeks. No active presurgical treatment used.

Fig. 11.—Superimposed cephalometric headplates of an infant with a complete unilateral cleft on admission and at age 12 weeks, after active presurgical oral orthopaedic treatment.

ii. The measurements from the anterior maxil lary implants to the midline plane remained constant.

iii. The outline of each implant on the films taken at 12 weeks lay vertically below the outline of the corresponding implant on the first headplate.

b. Lateral views

Each implant moved obliquely downwards and forwards to the same extent (*Fig.* 10).

2. *Unilateral Clefts*

a. Frontal views

i. The distance between the posterior implants remained constant. Where an attempt was made to deliberately increase or reduce this dimension, this change occurred.

ii. The anterior implant in the major segment (non-cleft side) moved towards the midline plane.

iii. The anterior implant in the minor segment remained stable (or moved slightly away from the midline where this was one of the movements sought after).

iv. The outline of the implants at the twelfth week lay further below the FMT–FMT line.

b. Lateral views

i. The maxillary and mandibular implants moved obliquely downwards and forwards to a similar extent except for the anterior maxillary implant.

Fig. 12.—Superimposed headplates of an infant with complete bilateral cleft on admission and at age 12 weeks after active presurgical oral orthopaedic treatment. Note mandibular and maxillary implants appear to move obliquely downwards and forwards while the premaxillary implant has followed a vertical pathway.

ii. The anterior maxillary implant in the major segment did not always move forward to the same extent as the other implants (*Fig.* 11).

3. *Bilateral Clefts*

a. Frontal views

i. The distance between the posterior maxillary implants remained constant. If it is necessary to increase or decrease this dimension this can be done.

ii. The anterior maxillary implants may be moved away from each other.

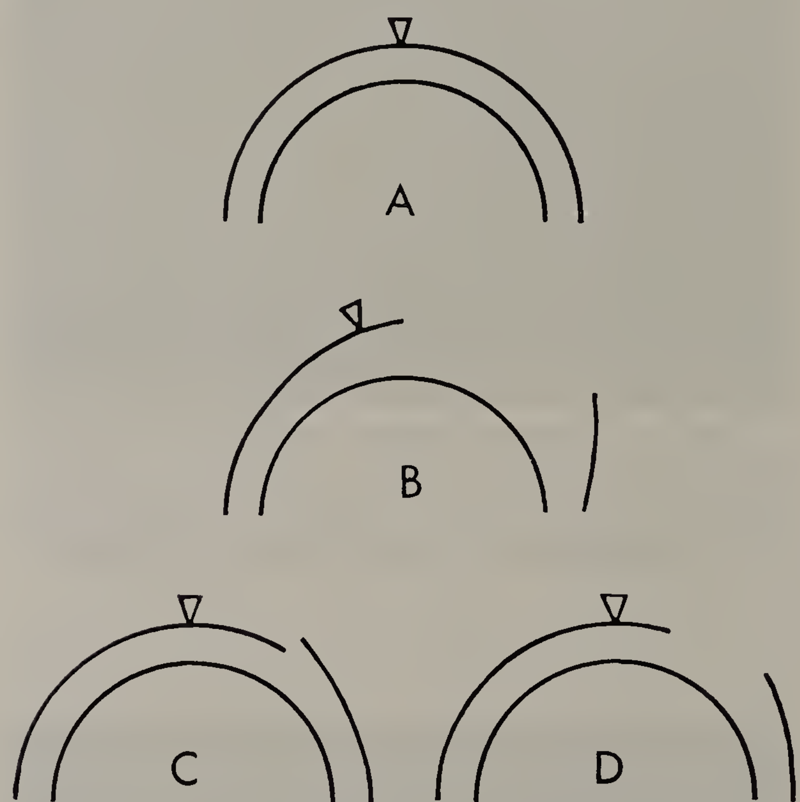


Fig. 13.—Diagrammatic representation of upper and lower gum-pad relationships. A, In the newborn normal infant. B, In the newborn infant with a unilateral complete cleft. C, Segmental relationship after correction—non-deficiency type. C, Segmental relationship after correction—deficiency type.

iii. The implant outlines on the second films lay further from the FMT plane.

b. Lateral views

i. Maxillary and mandibular implants moved downwards and forwards.

ii. The premaxillary implant dropped vertically—the restraint to the forward movement of the premaxilla is seen quite well in *Fig.* 12.

In both unilateral and bilateral clefts the movements shown to occur on the superimposed headplates were not so marked as the changes at the level of the gum-pads as recorded on the models.

Conclusions

1. Most of the movements sought for are produced.

2. Present-day presurgical appliances are limited in respect of what they can achieve.

CASE ANALYSIS AND TREATMENT PLANNING

As has already been stressed this should be carried out at the outset after consultation with the surgeon involved in treating the patient. In this section only complete unilateral or bilateral clefts will be considered, i.e., ' pure clefts ' (Pruzansky, 1966). It does not include the management of infants with postalveolar clefts which are considered in other recent publications (Pielou, 1967; Poswillo, 1968; Robertson, 1968; Burston, 1969) or other rare variants (Robertson, 1970).

Unilateral Complete Clefts

Burston (1958), Volp (1970), and others have described the method of construction of appliances for presurgical treatment and I do not propose to consider this aspect. Burston suggests that the direction and degree of movement of the jaw segments aimed for is largely a matter of clinical judgement. It is the writer's view that a more precise base to treatment planning must be laid down and that treatment should follow an examination of the patient, the records, an analysis of the case, and treatment planning.

Recent work has helped to establish the limitations which exist and these are:—

1. Forward movement of the minor segment as postulated by Burston was not shown to occur in the tantalum implant studies. This is now accepted in planning treatment.

2. Existing appliances are not capable of moving the individual segments in a vertical direction.

3. There may be a deficiency of tissue. There is conflicting evidence here—Peyton (1931, 1934) stated there was probably little deficiency of tissue while Coupe and Subtelny (1960) and later Huddart and others (1969) concluded that there was an absence of tissue.

An examination of a newborn infant with a unilateral complete cleft will show that the initial deformity is composed of a *displacement* of the individual jaw segments which has occurred because of the division and a *deficiency* of tissue.

In the newborn *non-cleft* infant the upper gum-pad lies approximately 2 mm. labial and buccal to the lower and the superior labial fraenum coincides with the centre of the upper jaw and of the face (*Fig.* 13).

In the unilateral complete cleft the most common displacement is of the major segment which is deviated to the non-cleft side and is often more prominent (*Fig.* 13B). The minor segment position varies. The corrective movements which can be achieved are:—

1. The movement of the anterior end of the major segment mesially (i.e., towards the cleft side).

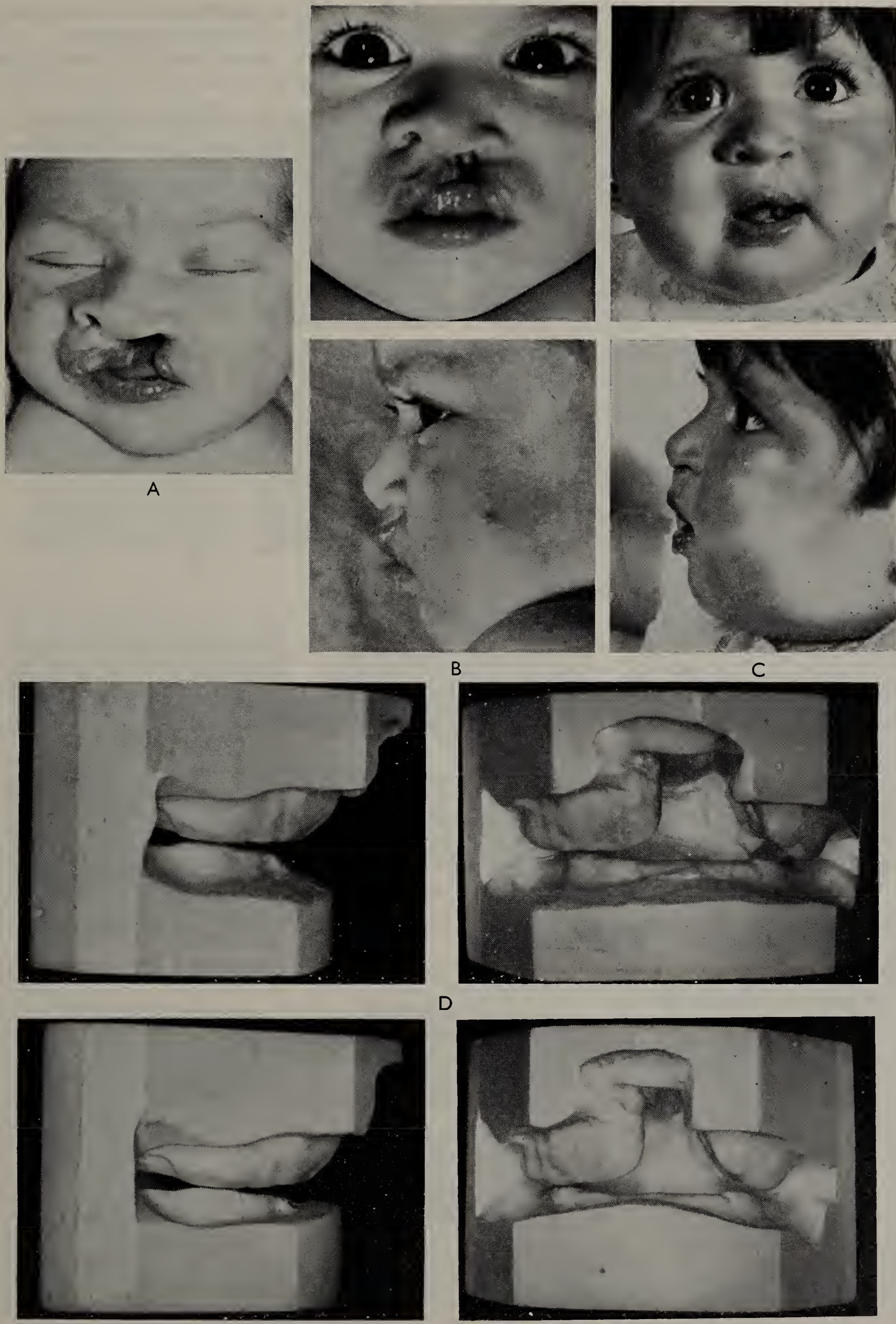


Fig. 14.—Complete unilateral cleft—deficiency type. A, Infant with complete unilateral cleft on admission. B, Infant at 12 weeks. C, Infant at age 5 months. D, Gum-pad relationship at birth. E, Gum-pad relationship at the twelfth week.

2. A restraining of the forward growth of the front of the major segment.

3. Buccal or lingual movement of the anterior end of the minor segment.

4. Buccal or lingual movement of the posterior ends of the major and minor segments.

A ' diagnostic set-up ' can be of assistance in determining whether there is tissue deficiency.

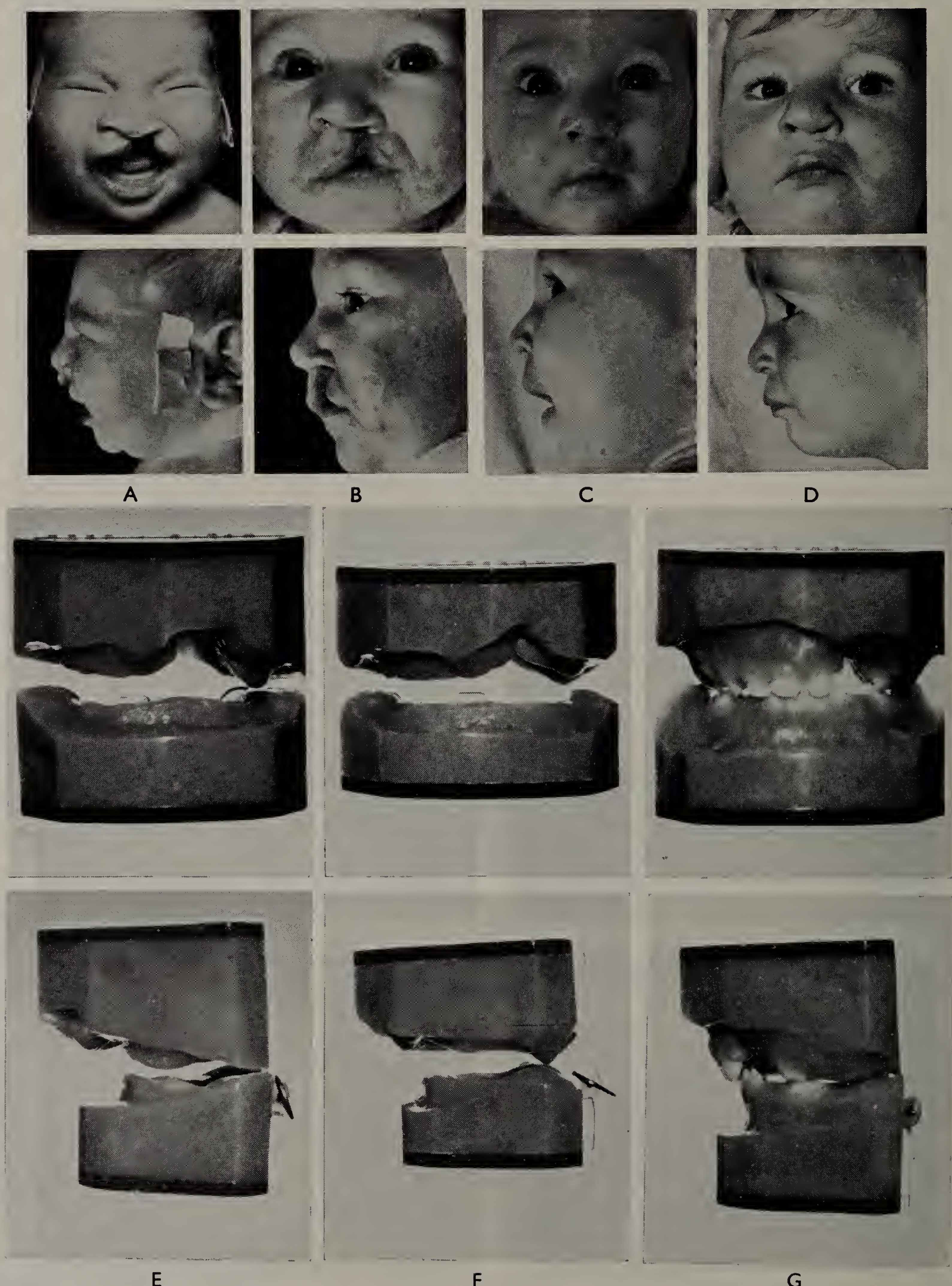


Fig. 15.—Complete unilateral cleft—non-deficiency type. A, Infant with complete unilateral cleft on admission. B, Infant at 12 weeks. C, Infant at 4 months. D, Infant at 2 years. E, Gum-pad relationship at birth. F, Gum-pad relationship at the twelfth week. G, Occlusion at 2 years.

The upper model is sectioned to determine the *required* movements which *can be achieved*, maintaining the upper gum pads at least 2 mm. buccal or labial to the lower except at the anterior end of the minor segment which should be 3–4 mm. buccal to the lower ridge. The two principal variants of complete unilateral clefts after completion of the corrective movements are shown in *Fig.* 13.

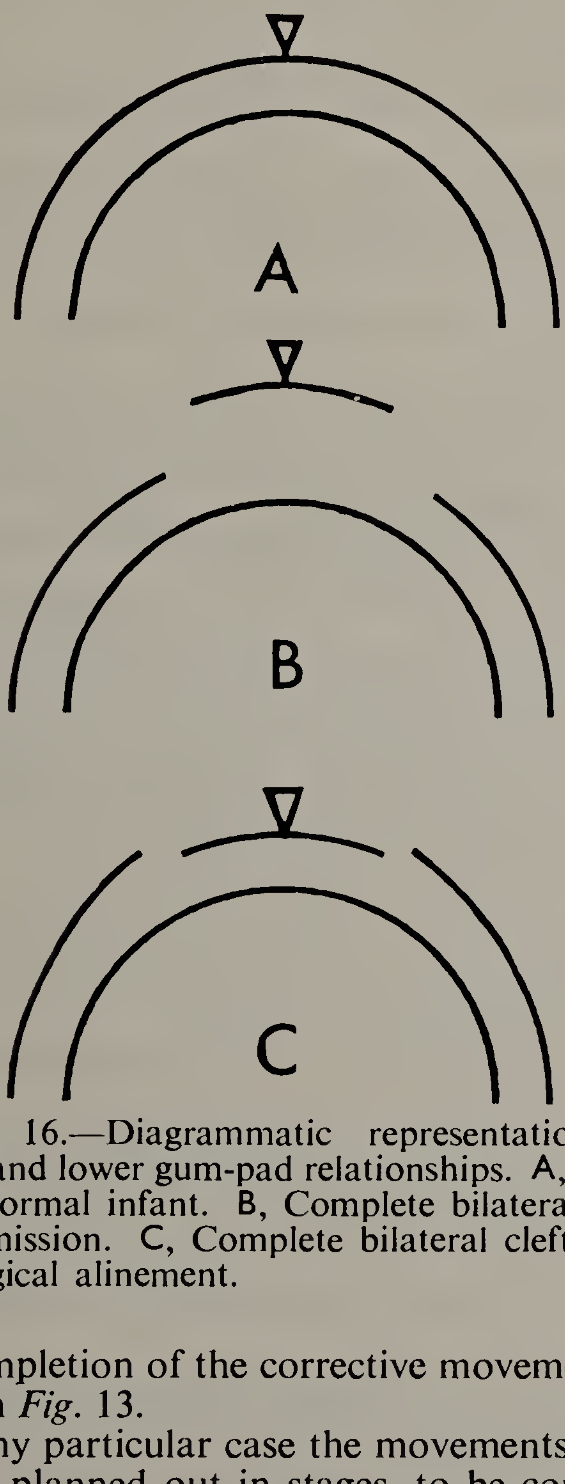


Fig. 16.—Diagrammatic representation of upper and lower gum-pad relationships. A, Newborn normal infant. B, Complete bilateral cleft on admission. C, Complete bilateral cleft after presurgical alinement.

For any particular case the movements sought are then planned out in stages, to be completed by the twelfth week (e.g., stage 1, correction of major segment position; stage 2, correction of position of anterior end of minor segment). This is illustrated (*Figs.* 14, 15) by 2 cases which at the outset appear superficially similar. In *Case* 1 it will be noted that after carrying out the diagnostic set-up there is a deficiency of tissue in the alveolar ridge area, while in *Case* 2 it has been possible to bring the anterior ends of the segments almost into contact with each other while maintaining the correct radial relationship between the upper and lower gum-pads.

Bilateral Complete Clefts

In a newborn infant with a complete bilateral cleft, the premaxilla is usually prominent: it may also be slightly rotated and tilted. The limitations outlined when considering unilateral clefts also apply in planning treatment for bilateral clefts.

The changes which can be produced in bilateral complete clefts are:—

1. Restraint on the forward translation of the premaxillary segment thus allowing the maxillary segments to catch up in an anteroposterior direction.

Fig. 17.—A, Infant with complete bilateral cleft on admission. B, Infant at age 12 weeks after presurgical oral orthopaedic treatment.

2. Buccal or lingual movement of the anterior ends of the maxillary segments.

3. Buccal or lingual movement of the posterior ends of the maxillary segments.

The premaxillary segments should be not less than 2 mm. anterior to the lower gum-pad after alinement, the posterior ends of the maxillary segments should lie a similar distance buccal to the ridge of the lower gum-pad, while the anterior ends of the maxillary segments should be 3–4 mm. buccal to the lower gum-pad (*Fig.* 16).

I am assured by surgical colleagues that given the choice between carrying out a repair of the child shown in *Fig.* 17A and that shown in *Fig.* 17B which is of the same infant 12 weeks later after presurgical oral orthopaedic treatment, they would prefer the latter.

GENERAL CONCLUSIONS

A study of the literature published during the past 20 years permits the following general conclusions:—

1. The case for presurgical oral orthopaedics is, as yet, unproven.

2. Anatomical studies suggest that presurgical oral orthopaedics is a reasonable procedure to employ.

3. Adequate longitudinal recording of treated cases is the essential prerequisite to a rational basis for the most efficacious treatment procedures.

4. Early bone-grafting is not helpful.

5. Treatment should be carried out only after thorough case analysis and treatment planning.

6. Present-day appliances are limited in what they can achieve and this is only one of several recognizable restrictions. If new appliances were developed this might reduce the limitations.

7. Existing appliances correctly employed produce the movements they are designed to.

Acknowledgements

I wish to thank my colleagues in the Manchester area for their helpful co-operation and in particular Mr. Ambrose Jolleys of the Royal Manchester Children's Hospital, who carried out the surgery.

I am indebted to Mr. C. R. Volp for technical assistance. The illustrations were produced by the Departments of Medical Illustration of the University of Manchester, Salford Hospital Management Committee, and the Dental School, Welsh National School of Medicine.

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DISCUSSION

The Chairman (Professor D. P. Walther) said that Dr. Robertson no doubt had difficulty in persuading the parents to allow him to do the implants. He wondered whether Dr. Robertson had ever considered delaying the closure of the hard palate.

Dr. J. R. E. Mills said that Dr. Robertson had reminded them that the idea of presurgical orthodontics had been going for something like 20 years. In the early days it was greeted by some of its protagonists as being the answer to everything, all other treatment being unnecessary. It was knocked by its antagonists as being useless and even mutilating. He had not believed either group, but he still did not quite know what to believe. It was a great pity that the earlier workers had not published their results. The antagonists tended to draw their own conclusions from this. Dr. Robertson had come on the scene comparatively late and had done a great deal to put this right with his meticulously careful analysis of the results of treatment. So far the children had not become very old; it took 20 years to get a cleft-palate patient to the age of 20! But Dr. Robertson had shown that the operation of bone-grafting was not a valuable operation, even the reverse, and one hoped that this view would be followed.

It was interesting to consider why bone-grafting had this effect. Obviously if the two halves of the maxilla were joined together it did not grow as it

would if the two halves were apart. Why was not this so? Was it a matter of the midline sutures being obliterated? Was it the surgical interference with the maxilla? Without the bone could the two halves be brought together by the 'functional matrix'? Perhaps Dr. Robertson could throw some light on these aspects.

Dr. Robertson was also doing some extremely valuable work on the actual effect of presurgical orthopaedics. It was a pity that he was not comparing children wearing the presurgical apparatus with those untreated by this method. This raised an ethical problem always. It would be useful if he could find someone who did not believe in his method so as to be able to make a comparison.

Dr. Robertson had stated fairly conclusively that as far as he had got the effect of the presurgical orthopaedics was to move the bony segments into a better position, but he had ducked the question whether it made these bony segments grow any more than they would otherwise. The evidence of this was very equivocal. Huddart, MacCauley, and Davis (1969) in their necessarily small series, have shown that the small segment grew more in their experimental than in their control group, but not to a statistically significant extent. Would Dr. Robertson chance his arm and say whether he felt subjectively that the apparatus made the small segment grow more than it otherwise would have done?

Mr. G. Wreakes said that he had noted that the bone-grafted cases were much inferior to the non-bone-grafted, and asked whether this was a reflection not so much of the failure of the bone-graft but of the extra surgical manœuvres involved, either initially in preparing the soft-tissue pocket for the bone-graft or because a secondary operation was involved.

Professor B. C. Leighton regretted that there was not time for a long discussion. Dr. Robertson had mentioned the overjet of the gum-pads at birth and said he thought this should be 2 mm. Although the overjet probably differed from one population to another he did not himself feel that the population in Manchester was so different from that in London that the overjet should vary by as much as 3 mm. In London it was an average of 5 mm. and it varied between 0 mm. and 10 mm. This problem of variability was going to be a constant one for Dr. Robertson in determining how much overjet to give the child. If he reduced it to 2 mm. at birth this was sailing dangerously near to an ultimate prenormal occlusion. Perhaps this was made necessary by the need to provide space for the lip repair but he felt it might be dangerous to justify it on the ground that it was felt that the overjet should be 2 mm.

Dr. N. R. E. Robertson, in reply to Professor Walther's question concerning the difficulty of obtaining parental consent to the insertion of implants, said that until now no parents had suggested that they did not wish this to be done. He did not know whether this was some reflection on his persuasive powers. Professor Björk's work on implants was sufficient for it to be said that it was not a harmful procedure and Dr. Robertson's work since carrying it out on cleft-palate patients confirmed this.

With regard to the timing of the soft- and hard-palate repairs, some surgical colleagues preferred to do a soft-palate repair at the third month, leaving the hard-palate repair until later. Whilst others preferred to do hard and soft palates together at around the twelfth month. When left, the hard-palate repair was done at the age of $4\frac{1}{2}$–5 years.

He agreed with Dr. Mills' comments and deplored the lack of published results from old established units who are using presurgical orthodontic methods. He had tried where possible to stimulate colleagues in the field to publish their results and felt that Dr. Mills' point was a very valid one.

Why was there a restriction in the anteroposterior growth? This was something which he personally would like to know more about and he would enjoy going into a speculative discussion on this with Dr. Mills privately.

With regard to the treated versus untreated presurgically he was now in a situation in which he could redeploy his forces and examine this problem, nevertheless he would value collaboration from any other centre. He had already invited this both before this Society and also in personal communications. Not everyone seemed sufficiently enthused to involve himself in the very considerable work of collecting data. If anyone would like to follow it up he would be delighted to meet him.

Dr. Mills had asked about the growth of the segments. This was something he also would like to know about but he was not prepared to make a subjective comment.

In reply to Mr. Wreakes, Dr. Robertson thought that the failure of bone-grafts was not related to further surgical interference. The programme was planned from the outset and is given in detail elsewhere (Robertson, 1969). He would merely reiterate that the bone-graft was inserted at the fifteenth month and in order to allow them to do this a bed or pocket was prepared in advance in which bone was placed through a simple small incision in the buccal sulcus, so that he would not feel the failure of the graft related to these additional soft-tissue surgical manœuvres. He believed this was borne out also by animal studies (Strenstrom and Thilander, 1967; Thilander and Strenstrom, 1967) which had been carried out which showed that there was a similar growth restriction occurring where grafted bone was placed and this was not related to the soft-tissue surgery involved.

Dr. Robertson said that he accepted Professor Leighton's remarks with regard to his own sample. The figures which he quoted in the paper were those which he had been using for some time and they were felt to produce reasonable results. The figure of 2 mm. should be regarded as a definite minimum beyond which one would produce a reverse incisor arrangement on the eruption of the deciduous incisors.

A vote of thanks to the speaker, proposed by the Chairman, was carried by acclamation.

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REPORTS OF MEETINGS

ORDINARY MEETING, 13 October

An Ordinary Meeting of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 13 October, 1969, at 6.30 p.m., with Mr. J. H. Gardiner, President, in the Chair.

The President said that he was sorry to announce the recent death of two very old-standing members, Mrs. Joan Webb of Ringwood, and Mr. D. H. Oliver, M.C., of Winchmore Hill.

Apologies for Absence

Apologies for absence were received from Mr. D. Munns and Mr. G. D. Everard.

Minutes

The Hon. Secretary (Mr. M. S. E. Gould) read the Minutes of the Country Meeting held at Leeds University on Friday and Saturday, 11 and 12 April, 1969. These were confirmed and signed as a correct record.

Introductions to the President

The following members whose elections had been confirmed at a previous meeting were introduced to the President and signed the Obligation Book:—

Mr. P. J. Griffiths
Mr. A. Becker
Mr. P. G. Arnold

Candidates for Election

The following were elected to Ordinary Membership:—

Mr. D. Hutchinson, L.D.S., B.Ch.D.(U. Leeds), D.Orth.R.C.S.(Eng.), 61 Plantation Gardens, Wigton Lane, Leeds 17, Yorks.

Dr. J. F. Jefferys, B.D.S.(U. Sydney), M.D. (U. Nijmegen), 7a Queen Victoria Road, High Wycombe, Bucks.

Mr. H. G. Lewis, F.D.S., D.Orth.R.C.S. (Eng.), 17 Maytree Road, Chandler's Ford, Hants.

Chapman Prize

The President announced that the winners of the Chapman Prize were Mr. T. P. Bass and Mr. C. D. Stevens.

Presidential Address: Education

The President then delivered his Presidential Address, following which a panel of six experts demonstrated the various pieces of audiovisual equipment which were in the hall. In the absence of a discussion Mr. W. A. B. Brown gave a vote of thanks which was passed with acclamation.

ORDINARY MEETING, 10 November

An Ordinary Meeting of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 10 November, 1969, at 6.30 p.m., with Mr. J. H. Gardiner, President, in the Chair.

The President welcomed all those present and extended an especial welcome to any visitors who were attending the meeting. He hoped they would take part in any discussion following the two papers to be presented.

He called on the Secretary to read the Minutes of the previous meeting.

Minutes

The Hon. Secretary read the Minutes of the previous meeting which were confirmed and signed as a correct record.

Introduction to the President

Mr. J. F. Jeffries was introduced to the President and signed the Obligation Book.

Candidates for Election

The following candidates were elected:—

Ordinary Membership

Mr. K. Sissons, L.D.S.(U. Leeds), 58 Thornstree Drive, West Monkseaton, Whitley Bay, Northumberland.

Corresponding Membership

Mr. Børge Johannesen, L.D.S.(U. Durh.), Gate 23, 7000 Trondheim, Norway.

Dr. Milton Panzer, D.D.S.(Temple U.), M.S.Orth.(U. Iowa), 2001 Colchester Road, Flint, Michigan 48503, U.S.A.

Vocational Registration and Specialist Lists

The President reminded members that, through the post, they had received a copy of a

letter sent on their behalf to Mr. H. Smith of the General Dental Council. The Council's request had been received during the holiday period, at a very difficult time. The Council of the Society had done their best to reply to the letter. Members might have reservations about it or suggestions for its improvement. He asked that they should put these in letter form and address them to the Secretary.

If there were sufficient the Council would consider whether or not a General Meeting should be held on this very important matter.

Mr. F. Allen asked if some time might be set aside in an Ordinary Meeting to discuss the matter.

The President pointed out that this was against the Constitution of the Society, but if Mr. Allen cared to put his comments in letter form and send this to the Secretary it would certainly be considered.

The President went on to introduce Dr. J. D. Atherton who was to deliver a paper entitled: '*A Method for Retroclining Lower Incisors in Class III Malocclusions*'.

Following the discussion on Dr. Atherton's paper, Mr. C. C. Knowles read a paper entitled: '*The Long-term Results of Mandibular Osteotomy: An Interim Report on the Treatment of Young Subjects*'.

ORDINARY MEETING, 8 December

An Ordinary Meeting of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 8 December, 1969, at 6.30 p.m., with Mr. J. H. Gardiner, President, in the Chair.

Apologies for Absence

Apologies for absence were received from Mr. T. Jason Wood, Mr. A. C. Campbell, Mr. R. W. Willcocks, and Mr. N. Upson.

Minutes

The Hon. Secretary read the minutes of the previous meeting, held on Monday, 10 November, 1969, which were confirmed and signed as a correct record.

The President added that there had been a most gratifying response to his invitation at the last meeting for comment on the representation by the Council of the Society to the General Dental Council. He thanked members for their help.

The President went on to call on Mr. D. G. Huggins from Chester and Liverpool, who was to read a joint paper by himself and Mr. L. J. McBride entitled: '*A Cephalometric Study of the Eruption of Lower Third Molars following the Loss of Lower Second Molars*'.

This was followed by a paper by Mr. R. D. Howard: '*The Congenitally Displaced Maxillary Incisor: A Differential Diagnosis*'.

ORDINARY MEETING, 12 January

An Ordinary Meeting of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 12 January, 1970, at 6.30 p.m., with Mr. J. H. Gardiner, President, in the Chair.

The President welcomed all those present to the meeting. He added his wishes for a very happy new year to members.

Apologies for Absence

The Hon. Secretary announced that apologies for absence had been received from Mr. T. Jason Wood, Mr. C. P. Hannan, Mr. R. T. Broadway, Mr. A. C. Campbell, and Mr. A. R. Campbell.

Minutes

The Hon. Secretary read the Minutes of the Ordinary Meeting held at Manson House on Monday, 8 December, 1969, which were confirmed and signed.

Candidates for Election

The President advised members that Sir Kenneth Thomas Adamson had been appointed as an Honorary Member of the Society.

Sir Kenneth was exceedingly well qualified to be an Honorary Member. He had been created a Knight in 1968 for his services to dentistry. He had been in specialist orthodontic practice since 1929. He was a Senior Lecturer in the Dental Department of the Medical School. University of Melbourne. There was a long list of his qualifications.

Members showed their approval by a show of hands.

Approval of the election of the following candidates was indicated by a show of hands:—

Ordinary Membership

Miss M. A. Betteridge, 114 Barnfield Wood Road, Beckenham, Kent.

Mr. M. H. Dods, 79 Brook House, Town Square, Basildon, Essex.

Mr. N. Flood, 17 Upper Fitzwilliam Street, Dublin 2, Eire.

Mr. A. B. Keiller, 23 St. Georges Road, Cheltenham, Gloucestershire.

Mrs. L. Laxton, 3 East Hill, Colchester, Essex.

Mrs. S. A. Lentin, 259 Strand Lane, Radcliffe, Lancashire.

Mr. L. J. McBride, 66 Rowcliffe Avenue, Chester, Cheshire.

Miss M. P. MacKenzie, Flat 1, 38 Murray Road, Northwood, Middlesex.

Mr. I. A. Reynolds, Wentworth, Newport, Pembrokeshire.

Mr. J. S. Spencer, 10 Heathfields, Sandrock Road, Tunbridge Wells, Kent.

Mr. G. D. Thomas, 63 Sketty Road, Swansea, SA2 0EN.

Mr. T. G. B. Wilson, 12 The Avenue, Colchester, Essex.

Corresponding Membership

Mr. I. D. Tippett, 21 Lynette Avenue, Beaumaris, Victoria, Australia.

The President welcomed visitors present at the meeting and invited them to take part in the discussion.

He introduced the first speaker, Mr. J. G. McCracken, a Lancashire man who had been born, bred, and trained in Lancashire. He had also been to Scotland—Edinburgh and Dundee. Congratulations were due to him on his new appointment as Consultant to North Lancashire.

He invited Mr. McCracken to read his short paper entitled: '*Rapid Maxillary Expansion as an Integral Part of Orthodontic Treatment*'.

This was followed by Mr. K. G. Isaacson reading: '*Overbite and Facial Height*'.

ORDINARY MEETING, 29 February

An Ordinary Meeting of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 29 February, 1970, at 6.30 p.m., with Mr. J. H. Gardiner, President, in the Chair.

The President announced the recent death of Professor Sheldon Friel of Dublin. He had been one of the Society's oldest members, having been a member since 1910.

He had had the distinction of being the one man who had 'put Mr. Edward Angel in his place—but with a degree of Irish humour which enabled him to live afterwards!'

Professor Friel had been an Honorary Member of the Society since 1959 and had been President at least once on an earlier occasion. His was a very great name in the profession.

The President called on members to stand and honour his name. The assembly stood in silence for a few moments.

Minutes

The Hon. Secretary read the minutes of the Ordinary Meeting held on Monday, 12 January, 1970. The minutes were confirmed and signed.

New Members

The following members were introduced to the President, after having signed the Obligation Book:—

Miss M. P. Mackenzie, Miss M. A. Betteridge, and Mr. D. Thomas.

Candidates for Election

Mr. D. A. Lawrie, 1 North Guildry Street, Elgin, Moray, Scotland, a candidate for election to ordinary membership, was unanimously elected on a show of hands.

Nominations for Council office

The Hon. Secretary drew the meeting's attention to Bye-law 19, whereby nominations for Council office for 1970/71 might be made by four properly qualified members, if received in writing by the Secretary at least 7 days prior to the Ordinary Meeting on 9 March, 1970.

The President welcomed visitors to the meeting and expressed the hope that they would take part in the discussion following the presentation of the paper.

They were fortunate in having Mr. T. P. Bass and Mr. C. D. Stephens present. Mr. Stephens was from the Orthodontic Department of the Royal Dental Hospital, and previously of Guys Hospital.

Mr. Bass had 'moved around very many dental hospitals' and was now in a position to write an authoritative 'Which'! Mr. Bass and Mr. Stephens had worked as a team in producing the Prize Essay. Mr. Bass would read it and Mr. Stephens would answer the questions afterwards.

He added that they were fortunate also in having Dr. Waters present at the meeting.

Mr. T. B. Bass presented the Prize Essay: '*Some Experiments with Orthodontic Springs*'.

The President thanked Mr. Bass and went on to introduce Dr. Waters, a physicist at the Royal Dental Hospital, who was to open the discussion.

ORDINARY MEETING, 9 March

An Ordinary Meeting of the Society was held at Manson House, 26 Portland Place, London W.1, on Monday, 9 March, 1970, at 6.30 p.m., with Mr. J. H. Gardiner, President, in the Chair.

Minutes

The Hon. Secretary read the minutes of the Ordinary Meeting of the Society held on Monday, 9 February, 1970, which were confirmed and signed as a true record.

Apologies for Absence

Apologies for absence had been received from Mr. T. Jason Wood, Mr. D. Foster, Mrs. Grundy, and Mr. and Mrs. D. Robertson Ritchie.

Candidates for Election

The following were elected to Ordinary Membership by a show of hands:—

Mr. B. J. Selwyn-Barnett, 76 Northiam, Woodside Park, London, N.12.

Mr. E. A. Walsh, 2 Tycehurst Hill, Loughton, Essex.

The President introduced Miss M. Campbell-Wilson who was already known to many of those present because, although she had qualified in Liverpool, she had been in London, the Home Counties, Bristol, and had recently been appointed Consultant to the Derby area.

He called on Miss M. Campbell-Wilson to present her paper entitled: '*Report on the Occlusions and Dentitions of a Group of Skulls excavated at a Cairn Cemetery in Fife*'. Following Miss Campbell-Wilson, Mr. T. O. Tweedie

read a paper by himself and Mr. J. H. Gardiner entitled: '*The Efficacy of Dental Welding Machines*'.

NORTHERN MEETING, 21 April

A NORTHERN MEETING of the Society was held in the Mathematics Building, Manchester University, Oxford Road, Manchester, on Tuesday, 21 April, 1970, at 5.30 p.m.. The President, Mr. J. H. Gardiner, was in the Chair and 55 members and visitors were present.

The PRESIDENT welcomed members and visitors from near and far and said how pleased he was to hold this meeting in Manchester.

Minutes

The Minutes of the Ordinary Meeting held at Manson House on 9 March were read and confirmed and signed by the President.

Apologies for Absence

Apologies for absence were received from Professor B. C. Leighton, Dr. J. R. E. Mills, Mr. J. S. Rose, Miss J. Ritchie, Mr. Frankland, and Miss C. Hamilton.

Announcement

The HON. SECRETARY reminded members of the Country Meeting in Brighton on 14, 15, and 16 May, and of the Regional Meeting to be held in Aberdeen on 23 October, 1970.

The PRESIDENT introduced Dr. W. Russell Logan and asked him to read his paper entitled: '*The Clinical Management of the Fränkel Appliance*,'.

The President proposed a vote of thanks to Dr. Russell Logan and to all who had contributed to the discussion. The vote of thanks was passed with applause.

The President thanked Dr. Robertson and all those who had helped with the arrangements for the meeting.

RESEARCH MEETING, 14 May

THE RESEARCH MEETING of the Society was held at the Bedford Hotel, Brighton on 14 May, 1970. The President, Mr. J. H. Gardiner, occupied the Chair and research papers were presented as follows:—

2.00 p.m. Mr. A. K. Tipnis: '*A Preliminary Survey into the association of the Frankfurt-mandibular-plane Angle with Interdental "S" and Incisor Relationship*'.

2.30 p.m. Messrs. J. F. Gravely and D. B. Johnson: '*Discordant Hypodontia in Monozygotic Twins*'.

3.00 p.m. Messrs. D. M. Menezes and T. D. Foster: '*Comparisons of Craniofacial Features in Monozygous and Dizygous Triplets*'.

3.30 p.m. Tea.

3.45 p.m. Mr. J. D. Stahan and Dr. J. R. E. Mills: '*A Preliminary Report on the Severing of Gingival Fibres following Rotation of Teeth*'.

4.00 p.m. Mr. S. N. Bhatia: '*A Longitudinal Study of the SN-mandibular-, Frankfurt-mandibular- and Maxillary-mandibular-Plane Angles*'.

4.30 p.m. Dr. J. K. Luffingham: '*A Study of the Buccal Forces exerted upon Teeth during Finger-sucking*'.

These papers were followed by a Civic Reception by the Mayor of Brighton in the Royal Pavilion.

ANNUAL GENERAL MEETING, 15 May

THE ANNUAL GENERAL MEETING of the Society was held in the Sussex Room of the Bedford Hotel, Brighton, at 9 a.m., on Friday, 15 May, with the President, Mr. J. H. Gardiner, in the Chair.

Minutes

The Minutes of the last Annual General Meeting were read by the Secretary and signed by the President as a correct record.

Election of Officers

The PRESIDENT proposed that the following Officers, as listed in the agenda, be elected for the following year:—

President:	Professor B. C. Leighton
Immediate Past President:	Mr. J. H. Gardiner
President Elect:	Dr. J. R. E. Mills
Senior Vice President:	Mr. S. G. McCallin
Vice President:	Mr. J. S. Rose
Treasurer:	Mr. J. P. Moss
Secretary:	Mr. M. S. E. Gould
Assistant Secretary:	Miss J. G. Ritchie
Editor:	Dr. J. D. Atherton
Curator:	Mr. R. D. Howard
Librarian:	Mr. A. C. Campbell.

The proposal was carried.

Election of Councillors

The PRESIDENT said that Mr. R. T. Broadway and Mr. W. A. B. Brown would continue in office until 1972, having been elected as recently as 1969. This left three vacancies, as Mr. C. P. Adams, Mr. W. Frankland, and Mr. R. W. Willcocks had now completed their 3-year term of office. They were sorry to lose the services of these good men. There were five nominations, which showed considerable interest on the part of members. A ballot was therefore necessary.

It was agreed that Mr. E. V. Bird and Mr. J. S. Beresford be appointed to act as tellers.

The result of the ballot (announced later) was that Mr. A. J. P. Cousins, Mr. D. G. Huggins, and Mr. C. D. Parker had been elected.

Election of Two Auditors

The President thanked Mr. P. H. Burke and Mr. A. J. Walpole Day for their past services as Auditors and announced that they had very kindly agreed, if requested, to continue in office.

Miss J. H. Ritchie proposed that Mr. Burke and Mr. Walpole Day be invited to continue as Auditors. Mr. A. H. K. Price seconded.

There were no other nominations and the proposal was carried.

Hon. Treasurer's Report

Mr. J. Rose said that the result for the year showed a surplus of £545 which was an increase of £69 over 1968. This figure was accounted for by a decrease in expenditure rather than a rise in income. In turn the decrease in expenditure was mainly attributed to a small profit made from the Leeds Country Meeting, in contrast to a deficit of £140 on the Jubilee Meeting in 1968. Here Mr. Rose said he should like to pay tribute to the manner in which the Honorary Secretary organized the last Country Meeting. It was the first time that the Society had had to deal with the financial organization of accommodation at a university hostel. Owing to the very efficient administration the Society was not called upon to subsidize this event, and much credit is due to Mr. Gould and Miss Ritchie for their efforts.

On the income side there was little change, but Mr. Rose said he would again like to acknowledge the help of the Honorary Librarian with the sale of the Society's Transactions.

This year we had again increased our holding of investments, and members will have noted the purchase of two new stocks to the value of approximately £1000.

Mr. Rose said he would once again remind members of the advantage to the Society of subscribing to the *Dental Practitioner*. The Society was committed to guarantee two hundred subscriptions to this journal. For each subscription less than two hundred the Society was charged £3·15. This year the short-fall account was £63. By taking the *Dental Practitioner* not only did members have the advantage of reading the Proceedings of the Society before the Transactions are published but they also contribute materially to the finances of the Society.

As this was the last Treasurer's report that he would have the honour to present, he would take this opportunity of acknowledging the help and advice that he had received from the Officers, Council, and Honorary Auditors of the Society. In handing over the account to his successor, Mr. James Moss, he hoped that he would find them in as satisfactory a condition as they were when Dr. Beresford passed them to him. Mr. Rose knew that they would be in good hands.

The President said that it was with great regret that he learned of Mr. Rose's retirement from the office of Treasurer, which he had done exceedingly well.

Mr. L. A. Usiskin asked how members who were subscribing to the *Dental Practitioner* could confirm that the publishers knew that they were members of the B.S.S.O.

Mr. Rose replied that the publishers, John Wright & Sons Ltd., were the Society's own publishers as well as publishers of the *Dental Practitioner* and had the membership list of the Society. Earlier this year he had seen the publisher's list of subscribers to the *Dental Practitioner* and had checked it against the membership list of the Society. The publishers were aware of the problem.

Mr. A. C. Campbell said that the Society had always been lucky in having Treasurers of considerable calibre and Mr. Rose had been no exception. He had held the office since 1963. He had seen eight Presidents come and go and three Secretaries, and had been a great help on a general Society basis and on a personal basis. Without his help the other officers could not have done their jobs satisfactorily. Members might not always appreciate just what the Treasurer did. He was not simply the chap who received the members' money and disbursed it. He took a very active part in all the Society's affairs, although in Council his principal concern was to advise upon financial matters. They were all most grateful to Mr. Rose for his services as Treasurer and looked forward to his continuation in office on the Council in other spheres of activity.

Mr. Campbell seconded the Report. On the motion of the President the Report was adopted. A vote of thanks was carried by acclamation.

Hon. Secretary's Report

Mr. M. S. E. Gould said that the past year had been quite eventful and had seen both a quickening and broadening of the activities of the Society.

Last year the Country Meeting was held at Bodington Hall, Leeds, and was attended by 121 members and visitors who signed the attendance book and quite a few others who did not. The innovation of a dance after the Annual Dinner had proved to be a success and so arrangements have been made for dancing to follow the Annual Dinner that night.

During the year there had been six Ordinary Meetings at Manson House where the attendances had averaged 104 members and visitors; this was slightly higher than in the preceding 2 years.

The amenities at Manson House had been much improved by the installation of two neck microphones at the instigation of the President, who had also been instrumental in acquiring the splendid new lectern of which he would be speaking later.

A further Meeting was held at Manchester on 21 April, 1970, in conjunction with the Manchester and District Orthodontic Study Group. Fifty-five members and visitors were present and Mr. Gould said he was much indebted to the President and to Dr. Robertson and the Committee of the Manchester Group for the excellent arrangements for the meeting.

The experiment of holding Ordinary Meetings at centres away from London had proved successful and had been welcomed by members. There is no doubt that these regional meetings have become a regular feature of the Society's calendar.

During the next session a whole day meeting would be held at Aberdeen on 23 October and, in all probability, there would be a meeting at Birmingham next spring.

The membership of the Society had continued its steady growth and although 11 Ordinary Members and 3 Corresponding Members had resigned and, sadly, 3 Ordinary Members had died, 1 of which was our most senior member, Professor S. Friel, 22 new Ordinary Members and 3 new Corresponding Members had been admitted and the total membership was now well over 600.

The Council had been extremely active throughout the year and had met on many occasions and in many places, including Edinburgh and Belfast. Undoubtedly the most important matter discussed had been that of Vocational Registration and Specialist Lists. The Society was requested by the General Dental Council to submit views on ‘ The Implications for Dentistry of the Recommendations of the Royal Commission on Medical Education ’. The reason for this request by the General Dental Council was stated as being because they had resolved to accept the principle of Vocational Registration as set out in the Todd Report and to accept the responsibility for such registration.

This matter was considered urgently by the whole Council and a subcommittee, consisting of the President (Chairman), Mr. W. Frankland, Dr. J. R. E. Mills, Miss J. Ritchie, and the Secretary, was set up to draft a reply. The subcommittee report which was approved by the Council was submitted to the General Dental Council on 28 August, 1970. A copy of the letter embodying the report was distributed to all Ordinary Members.

As a result of criticisms by members two amendments were made subsequently and these have been accepted by the General Dental Council with whom the matter now rests.

Although the British Medical Association and the British Dental Association have shown no enthusiasm for Vocational Registration it is possible that, following the deliberations of the General Dental Council, further action will be required and so the subcommittee is still in existence and will be meeting whenever necessary to deal with contingencies. The Secretary will ensure that members are fully informed of any developments and of any action taken.

There was no doubt that this matter and the related question of an appropriate training programme for registered specialists were being considered in detail by authorities and bodies, other than the General Dental Council, who have not seen fit to approach the Society for its views. It was, therefore, the Council's opinion that it was most important that requests from the General Dental Council for information should be responded to whenever requested since the Society represented the whole spectrum of orthodontic interests and not just one minor sector.

The Council were also actively reviewing the structure and organization of the Society and how best it could evolve to meet the changing needs and requirements of members. A subcommittee had been set up to deal with this matter and the views of the various regional orthodontic study groups and societies were being sought. Constructive suggestions and observations from individual members were also welcomed. Just one of the matters which must be resolved was whether the increase in the number of meetings held in the regions should be accompanied by a reduction in the number held in London.

The Secretary wished to express his thanks to Miss Ritchie for her efficient and unfailing support and to his fellow officers for their help and Counsel.

Mr. Gould begged to move the adoption of the report.

Mr. E. V. Bird suggested that if there were to be regional meetings there ought to be regional secretaries, under the authority of the main Secretary, to do all the major work. This seemed only fair as otherwise a heavy load fell on the Secretary's shoulders.

The President thanked Mr. Bird for his suggestion and said that he would certainly support it. As the Society was arranged at the moment it was fast killing off its able secretaries, each one of whom had to devote between two and three evenings a week to nothing but B.S.S.O. business. The organization of the meetings at Manson House and in the regions and the Annual Meetings, etc., was a tremendous task. He would ensure that the subcommittee considered the suggestion.

The President thanked the Secretary who had guided him exceedingly tactfully! This had to be done from a range of something like 160 miles. He was a man of unusual ability and it was to be hoped that a change in the organization could be made so as to make his lot a little easier than it had been up to now.

On the motion of the President the Report was adopted.

Hon. Editor's Report

Dr. J. D. Atherton said that he had no idea when he undertook the task of Editor of this Society just how much work was involved. This was largely because our previous Editor, Dr. Mills, had for so many years worked extremely well and efficiently and at the same time maintained the very high standard of our proceedings. Since relinquishing office Dr. Mills had constantly advised and helped the new Editor and Dr. Atherton would like to thank Dr. Mills very much indeed for this.

One of the difficulties the Editor of this Society had to overcome was to resolve three conflicting interests, which were:—

1. To encourage the presentation of original work and ideas suitable to a learned society such as the British Society for the Study of Orthodontics.

2. To present practical and clinical matters so that members are informed of current clinical practice and trends.

3. To see that all the above material is presented in such a manner that it is of interest to the 'live' audience that it is given before. In this respect the Editor is at a serious disadvantage compared with the editor of a journal who can accept papers without regard to the fact that they have to be heard as well as seen.

Dr. Atherton did not think that these interests were irreconcilable and the Editorial Committee intended that the monthly meetings would be of interest to as large a section of the membership as possible.

Members would have already read the letter concerning the plans for the monthly meetings. The system of holding a short paper followed by a longer paper was becoming almost traditional and proving its worth. It was interesting to note just how lively a discussion was after the short paper.

Finally the Editor said that the Committee would welcome offers of papers or suggestions for speakers for the forthcoming programme.

The reception of the Report was proposed by Dr. Atherton and seconded by Dr. Mills. The Report was adopted on the proposal of the President.

Hon. Curator's Report

Mr. R. D. Howard said that it had been a further quiet year for the Society's Museum. Material had been very kindly donated by Mr. J. K. Chmielewski, Mr. W. Frankland, and the Society's Curator for inclusion in the General Collection.

It had been mentioned by previous curators that the Museum was short of both instruments for making orthodontic appliances and orthodontic appliances of historic interest themselves. Perhaps he could repeat the request for instruments or appliances, the Curator hastened to add 'pre-1920 appliances' that members may have in their possession and that they would be willing to donate for inclusion in the Society's Museum.

The reception of the Report was proposed by Mr. Howard and seconded by Mr. T. Jason Wood. The Report was adopted on the proposal of the President.

Hon. Librarian's Report

Mr. A. C. Campbell said that the library continued to be active in the sale of copies of past and present Transactions of the Society. Stocks were adequate at the present time, although naturally many of the early volumes were in short supply or were unobtainable. He was glad to receive past copies from Members to add to the stocks of the Society.

Members were reminded that the library is housed at the British Dental Association's headquarters at 64 Wimpole Street, London. It included not only the Transactions of this Society but also those of the European Orthodontic Society and bound volumes of periodicals such as the *American Journal of Orthodontics*, the *Angle Orthodontist*, the *Dental Practitioner*, and *Dental Abstracts*, to which the Society was now adding *The Orthodontist*.

Finally Mr. Campbell repeated his thanks to Mrs. Oates for her untiring work and help in the sale of Transactions.

Mr. Campbell then moved the reception of this Report. The Report was seconded by Mr. J. H. Gardiner. The Report was adopted on the proposal of the President.

Any Other Business

Mr. F. Allan said that last autumn they had been asked to make comments on the recommendations for the training of orthodontists. The recommendations of the Council were based on the length of time a man had to be in a hospital to train to become an orthodontist, not the difficulty of passing an exam. or presenting case reports or having to go through a certain kind of training. This was the sort of thing that made it necessary for a man to stay in the hospital service and become an orthodontist. He felt that this was wrong. If the Council were concerned with the quality of an orthodontist, all they had to do was to make the diploma more difficult to get or set higher standards. To make a proposition that an orthodontist was one who spent years in the hospital service was completely wrong, and it was not right that the Council should be misused for this purpose.

Mr. E. V. Bird asked whether the Council were going to consider the report on orthodontic auxiliaries which appeared in the latest *British*

Dental Journal. Had the Council considered this report?

The Secretary said that the Council which had been meeting up till now was last year's Council and it was not considered proper for it to deal with this item, which would be placed on the agenda and come before the Council under the Presidency of Professor Leighton.

The President thanked members for their attendance and closed the Annual General Meeting.

COUNTRY MEETING, 15 May

The Country Meeting opened in the Sussex Room of the Bedford Hotel, Kings Road, Brighton, at 9.30 a.m., with the President, Mr. J. H. Gardiner, in the Chair.

The President welcomed all those taking part, especially the visitors.

Minutes

The Hon. Secretary (Mr. M. S. E. Gould) read the Minutes of the previous Ordinary Meeting, held in Manchester on 21 April. These were confirmed and signed as a correct record.

Life Membership

The President said that the Council proposed that Mr. J. F. Pilbeam, a retiring Senior Vice President, and Mr. A. Thornton Taylor, of Australia, be elected Life Members of the Society.

This was agreed.

Ordinary Membership

The Hon. Secretary read the following names of candidates for election to Ordinary Membership:—

Mr. D. E. J. Bowden, 98 Grove Park, Knutsford, Cheshire.

Mr. A. H. P. Davies, 18 Porth-y-Castell, Barry, Glamorgan, Wales.

Miss L. Nagasinghe, Dental Department, Perth Royal Infirmary, Perth, Scotland.

The names were approved.

The Programme of the Meeting was then presented, as follows:—

Friday, 15 *May*

9.30 a.m. 24th Northcroft Memorial Lecture: Dr. K. E. Thonner: '*Autogenous Transplantation of Unerupted Maxillary Canines: A Clinical and Histological Investigation over Five Years*'.

11.00 a.m. Coffee.

11.30 a.m. Paper: Mr. D. D. Di Biase: '*Mucous Membrane and Delayed Eruption*'.

2.00 p.m. Paper: Messrs. J. H. Martin and J. D. McEwen: '*Methods Available to Improve the Surface Hardness and Appearance of Study Models*'.

2.30 p.m. Paper: Mr. B. B. J. Lovius: '*Speech and Intelligence in Adult Cleft Palate Patients*'.

3.15 p.m. Tea.

3.45 p.m. Table Demonstrations.

7.00 p.m. for 7.30 p.m. Reception and Dinner Dance at the Bedford Hotel.

Lectern

The President said that not only had there been an exceedingly fine 24th Northcroft Memorial Lecture but this had been accompanied by an historical event, namely, the baptizing of the new lectern. Something like this had been required for some years. The one we had been using in Manson House was designed after a fourteenth century model and a number of our members felt that it was time the Society had an up-to-date lectern. This new one had been made by a British craftsman out of British oak and the

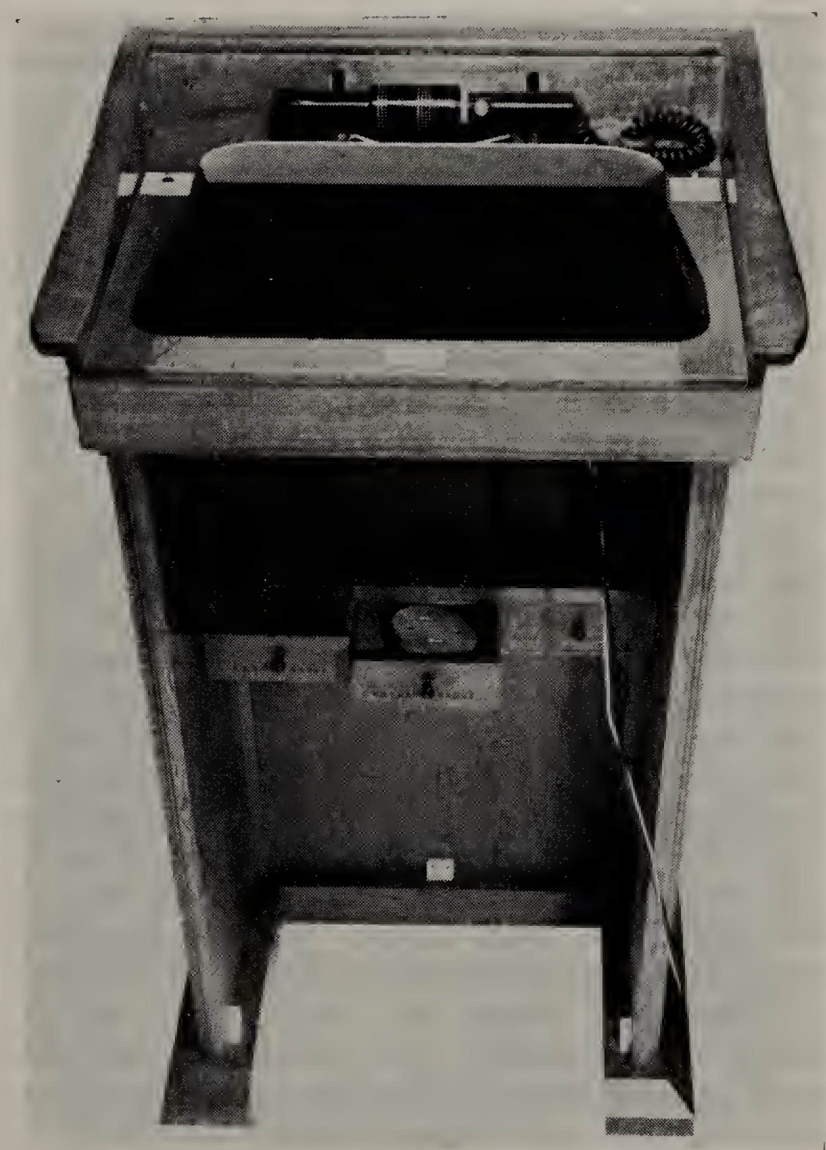

Fig. 1

badge in the front showed that it belonged to the B.S.S.O. The top had been designed to overcome the common fault of glare from the surface of the lecturer's notes being reflected backwards over his shoulder on to the projection screen, thus vitiating especially the image of coloured lantern slides. In this lectern (*Fig.* 1) also an attempt had been made to reduce the complex console of controls which so often confused visiting lecturers, and a special arrow pointer torch had been imported because, having an optical system, it shone a very bright arrow on to the screen. The donor was Mr. Russell, who had been most generous, as you will see when you examine this

lectern, for it not only had all these facilities to assist the lecturer but it was also portable so that it could be seen and used not only at Manson House but at all meetings of the Society wherever they may be held in the country. He felt sure that they would all wish to express their appreciation to Mr. Russell.

The vote of thanks to Mr. Russell was carried with acclamation.

Closure of the Meeting and Introduction of the New President

Mr. J. H. Gardiner said that the end of this Country Meeting brought with it a change in the pilotage of the ship. One could not accept a position such as that of President without learning something about the ship and this year had been a most interesting one. He had learned to appreciate the quality of this Society, evidenced by its long history, and he paid tribute to those early members who had laid such very firm foundations, both financial and procedural, on which our Society rested. It is obvious now that there was need for a national society through which could be channelled new methods of teaching, learning, and so on, and whoever envisaged the forming of such a society at the beginning of the century deserved to be congratulated, as also did all those hard-working officials who have served the Society since then.

He paid especial tribute to the Council, who had served over this last year. They had had to put up with a very amateur Chairman. The Secretary had only just taken over Secretaryship himself, so in addition to his own problems he had had to guide an apprentice Chairman and he had done exceedingly well. The incoming President could be assured of tremendous backing from the Secretary, who was absolutely tireless and really made sure that the hand on the helm was doing the right thing. He was personally most grateful to the Secretary for all he had done.

There were others too who made sure that things ran smoothly. For instance, when there were various needs in the projection department Mr. Alan Campbell came forward, and Dr. Mills, without any prompting, had been dealing with the lights during the lectures. The table planning for a banquet was quite a task; this was done quietly and without fuss by Miss Joan Ritchie, who also organized the reception. Mr. Jeff Rose had been responsible for a number of arrangements on which a great deal depended.

There were other people as well who made the year as a President possible. It involved being away from one's place of work and he was most grateful to Mr. Tony Price in particular and to Mr. Don Fraser. Thanks to them, when he was committed in London he had had no worries as to what was happening in Sheffield.

The new President had been chosen with great care and very wisely. There was no need to elaborate on his qualities. He was a man of patience and understanding and an exceedingly loyal friend. He had been a member of the Society since 1948 and had served as a Councillor, as Secretary, and as Curator. No man with better training for the task ahead could be found.

Professor Leighton was then installed as President of the Society.

The President (Professor Leighton) said that over the years the constitution of the Society had evolved in such a way that the President had to serve an apprenticeship in preparation for the moment when he took the Chair. Having served his apprenticeship he felt at the moment rather like a person who had climbed up to the starting point of the ' big dipper '. His 2 years had been spent on keeping his eyes steadily ahead and it was only now that he had looked over the side and had realized the awful height he had reached. He was about to go over the brow and to see what lay before him in the coming year. Perhaps the student facing his final examination felt very much the same.

It had occurred to him last night that he had an inheritance from Jim Gardiner that he could not possibly live up to. Jim had a facility for telling anecdotes which he did not himself possess. The Society might be said to be passing from anecdotage to dotage! There would be no funny stories from the new President; they would be spared that embarrassment.

Dr. J. R. E. Mills, in proposing a vote of thanks to Mr. Gardiner, said that orthodontic teaching had been his first and lifelong love; apart from his period in the Royal Navy he had never left it. Shortly after the War he became an adopted Yorkshireman. When he took over command of the Orthodontic Department in the Sheffield Dental Hospital it involved the use of one chair in the corner of the Conservation Clinic on Monday afternoon! Those who had seen the present Orthodontic Department would know what the Sheffield School owed to Mr. Gardiner. It was now one of the largest and best equipped in the country.

He had not confined himself to this. Many of them were members of Orthodontic Study Groups. These all owed their existence originally to the largest and most efficient of them, for which Mr. Gardiner had been responsible in Sheffield.

He was the first and so far the only one to run weekend courses for orthodontists. Although his love had been teaching, he had not neglected research and had a number of very useful papers to his name, of which his survey of a thousand Sheffield schoolchildren was widely quoted in the literature.

A year ago Mr. Gardiner had come to one of the pinnacles of his career with his installation as President of the Society. He had carried out those duties with his customary enthusiasm and

efficiency and it had been a great honour to serve as his Vice President.

Mr. Gardiner had travelled widely, not only through this country but abroad, taking fraternal greetings to other Societies.

He had also worked on the practical level and had almost built the new lectern himself. He had done something about sound reproduction at Manson House, where the qualities of this were much improved by his work.

It was with very great pleasure personally that on behalf of the Society he now proposed a very sincere vote of thanks to Mr. Gardiner for his year as President.

The vote of thanks was carried by acclamation and the Meeting was then closed.

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

Balance Sheet and
Income and Expenditure Sheet

FOR THE

YEAR ENDED 31 DECEMBER, 1969

COLE, DICKIN & HILLS,
CHARTERED ACCOUNTANTS, AUDITORS
18, Essex Street, Strand, London, W.C.2

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

INCOME AND EXPENDITURE ACCOUNT for the Year ended 31st December, 1969

31.12.1968 £	£		£ s. d.	£ s. d.
2		To *Museum Rent*		10 10 0
		,, *Meeting Expenses:—*		
	54	Hire of Hall	54 0 0	
	89	Refreshments	83 17 0	
	103	Reporting	148 8 6	
	10	Lanterns and Films	24 7 6	
	140	Country Meeting (Net) ..	*15 4 7* (Profit)	
	52	Northcroft Memorial Lecture	52 10 0	
	23	Sundry Items	12 11 0	
471				360 9 5
26		,, *Chapman Prize* (1969)		26 5 0
		,, *Printing*		
	1362	Publications	1378 18 3	
	318	General Printing and Stationery	329 6 11	
	101	Binding of Journals	19 8 0	
1781				1727 13 2
	5	,, *Insurance*	7 9 6	
	32	,, *Library and Journals*	117 1 10	
	190	,, *Postage*	205 3 2	
	200	,, *Secretarial Assistance*	200 0 0	
	26	,, *Honoraria*	26 5 0	
	73	,, *Accountancy*	78 15 0	
	16	,, *Accountancy previous year* ..	5 5 0	
	89		84 0 0	
	17	,, *Sundry Expenses*	19 3 0	
	21	,, *Depreciation of Furniture and Equipment*	16 3 9	
	5	,, *Repairs*	4 7 6	
	21	,, *Bank Charges*	19 10 3	
606				699 4 0
476		,, *Excess of Income over Expenditure for the year*		545 1 9
£3362				£3369 3 4

31.12.1968 £	£		£ s. d.	£ s. d.
	2585	By *Members' Subscriptions*	2575 9 11	
	18	Arrears Collected	77 15 2	
2603				2653 5 1
270		,, *Sale of Transactions*		262 9 6
338		,, *Interest Received and Accrued* ..		322 1 10
151		,, *Income Tax Recoverable*		131 6 11
£3362				£3369 3 4

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

BALANCE SHEET as at 31st December, 1969

31.12.1968 £	31.12.1968 £		£ s. d.	£ s. d.
		Accumulated Fund:—		
	5770	Balance at 1st January, 1969 ..	6245 13 0	
	476	Excess of Income over Expenditure for the year	545 1 9	
6246				6790 14 9
		Creditors and Reserves:—		
	1300	Publications Printing Reserve ..	1350 0 0	
	215	Sundry Creditors	212 6 1	
	9	Subscriptions in Advance ..	44 0 0	
	7	Petty Cash Accounts	21 7 8	
1531				1627 13 9
£7777				£8418 8 6

P. H. BURKE, A. J. W. DAY — *Hon. Auditors*

J. S. ROSE — *Hon. Treasurer*

31.12.1968 £	31.12.1968 £		£ s. d.	£ s. d.
		Fixed Assets:—		
		Furniture and Equipment Balance		
	54	at 1st January, 1969	35 0 0	
	2	Additions during the year ..	24 3 9	
	56		59 3 9	
	21	*Less:* Depreciation	16 3 9	
35				43 0 0
		Investments at Cost:—		
	751	Baker Perkins Holdings Ltd., 1144 Ordinary 10/– Shares	750 19 8	
	783	Boulton and Paul Ltd. 450 Ordinary 5/– Shares; 759 'A' Non-Voting Ordinary 5/– Shares	782 16 9	
		British Insulated Callenders Cables Ltd.		
	151	£150 7% Debenture Stock 1985/90	151 4 0	
	455	581 10/– Ordinary Shares ..	454 14 7	
	—	Clydesdale Investment Co. 370 Ordinary 5/– Shares	501 9 7	
	502	Coats Patons Ltd. 920 Ordinary 5/– Shares	502 3 6	
	509	Corporation of London £500 5¼% Stock 1976/79	508 10 9	
	745	Fisons Ltd. 279 Ordinary £1 Shares	744 12 0	
	1310	Liverpool Corporation £1516 4¾% Stock 1970/74	1310 5 0	
	478	Royal Insurance Co. Ltd. 200 Ordinary 5/– Shares	478 10 0	
	761	Sun Alliance and London Insurance Ltd. 210 £1 Ordinary Shares ..	760 13 7	
	—	U.S. Debenture Corporation Ltd. 770 Ordinary 5/– Shares ..	497 4 9	
6445				7443 4 2
		(Approximate Market Value at 31.12.1969 £7475 (31.12.1968, £8033))		
		Current Assets		
244		Income Tax recoverable		381 1 9
83		Prepayments and Dividends receivable		22 17 8
		Cash at Bank and in Hand		
	236	Westminster Bank Ltd.	*692 13 9 o/d*	
	19	P.O.S.B.	19 13 5	
	700	Deposit Account	1200 0 0	
	15	In Hand	1 5 3	
970				528 4 11
£7777				£8418 8 6

We have prepared the annexed Balance Sheet and Accounts from the books, records and information given to us and we certify them to be in accordance therewith. We have verified the investments and cash at Bank.

18, Essex Street, Strand, London, W.C.2.
5th March, 1970

COLE, DICKIN & HILLS
Chartered Accountants

SUBJECT INDEX

AUTHOR INDEX